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ABSTRACT

This report is based on the Alberta Education Energy Conservation Project - Phase II. The project was a follow-up to an earlier study, extending from June 1980 to June 1983, in which government funding and engineering manpower were used to conduct an energy management program in 52 selected pilot schools in 5 areas of the province. The report provides an outline of chronological events during the project as well as a quantitative evaluation of the effects of technical retrofit measures on various school buildings, dealing with such technical data as types of modifications undertaken, funds expended in specific schools, and overall effect of the measures on the subsequent energy consumption in each building. The background (Phase I) to the present project is presented, followed by discussions of the development of the Phase II effort, findings, conclusions, recommendations, and future aspirations. Information provided, supplemented by supporting documentation in 13 appendices, complements another survey dealing with a qualitative evaluation of the effect of the energy management program on school building users (administrators, principals, teachers, and custodians) in an attempt to gauge the effect of staff motivation efforts, curriculum additions, and technical modifications on the daily occupants of each building. (JN)

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Alberta Education
Energy Conservation Project
Phase II

Internal Evaluation

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Alberta Education
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Energy Conservation Project - Phase II: Internal Evaluation

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Alberta Education Energy Conservation Project - Phase II: Internal Evaluation

Executive Summary

This report is based on the Alberta Education Energy Conservation Project - Phase II. The project was a follow-up to an earlier project and extended from June 1980 to June 1982. Government funding and engineering manpower were used to conduct an energy management program in fifty-two selected pilot schools in five areas of the province.

This report is primarily written to serve as an outline of chronological events during the project. As well it deals with a quantitative evaluation of the effect of technical retrofit measures on various school buildings. The background, (Phase I) to the present project, which laid out much of the groundwork for this study, is covered. The development of the Phase II effort, findings, conclusions, recommendations and future aspirations are then discussed.

This report is designed to complement the survey report produced by the firm of Stanley Associates Engineering Ltd. The Stanley Associates document represents a qualitative evaluation of the effect of an energy management program on school building users. Their study involved an in-depth survey of occupants in the fifty-two pilot schools, from administrators and principals to teachers and custodians. It was an attempt to gauge the effect of staff motivation efforts, curriculum additions and technical modifications on the daily occupants of each building. The awareness, attitudes and specific concerns of building users was probed by the researchers.

This approach contrasts with the thrust of the in-house Phase II evaluation which deals more with the technical data, such as types of modifications undertaken, funds expended in specific schools, and overall effect of the measures on the subsequent energy consumption of each building.

In the Phase II report the success of technical retrofits and other effects are readily measured by monitoring energy performance of the school before and after. It was up to the Stanley Associates study, however, to approach the much more difficult task of trying to correlate the human element in the complicated equation of energy-using factors.

The Stanley Associates report is of interest to those who wish to have an insight into the present attitudes of Albertans toward the idea of energy conservation in schools.

Phase I of the Energy Conservation project represents several preliminary studies that the Department commissioned in 1978. The Department was prompted to do this for several reasons. School buildings are as bad or worse than other buildings for wasting energy. A combination of obsolete design, harsh climate, inefficient operation, infrequent maintenance and cheap energy costs have created this situation. School boards are often less able to deal with these problems than owners of other buildings because of tight budgets, lack of technical expertise, and the mentality of constructing schools based on lowest first costs. These facilities, then, offer great scope for energy efficiency improvement if only a workable mechanism for implementing changes was put in place.

Partly out of economic necessity and partly out of concern for the global energy situation, governments at various levels are taking the conservation option

seriously. The Alberta Government has addressed the problem through conservation initiatives in a number of departments. Alberta Education realized the necessity of instituting a program that would help school boards around the province to control their utility bills and improve their facilities.

Three studies were commissioned:

1. The Grande Prairie School District studied ways of saving energy through low/no cost motivational and operational measures.

2. The Calgary Board of Education report dealt with saving energy by spending funds on technical retrofits to structure and systems.

3. The Sweetgrass report researched energy efficient design considerations in the building of a new school for the Edmonton Public School Board.

One primary conclusion reached in these three studies was that energy could be effectively saved using any of the three approaches. The department gathered all study conclusions and recommendations together to produce a publication called "Guidelines for Conserving Energy in Alberta Schools" which was distributed to all schools. Another main recommendation was that an in-house engineering group in Alberta Education was needed to provide consulting services to school boards. This would relieve the lack of technical expertise felt by most boards.

The Phase II project was set up in response to these findings. It was judged preferable to apply an experimental program to a small number of schools initially before embarking on a greater scope of activities. The pilot project, using five engineers in five climatic zones around the province had three main objectives:

1. Test the practicability of "Guidelines for Conserving Energy in Alberta Schools".

2. Develop reasonable energy performance targets for schools in various climatic areas.

3. Conduct open-house "showcase schools" to demonstrate energy conservation to the community at large.

The fifty-two schools pilot project involved efforts in technical, motivational and student involvement aspects of energy conservation in schools. Each engineer was stationed in one of five project areas and given two years to implement an energy management program in about ten schools. This involved energy audits, energy balance analyses, retrofit and operational recommendations, tendering of projects, supervising installations, staff motivation, and evaluation of the effectiveness of all aspects.

Much of this report is a chronological account of the Phase I background and development and activities in the second phase.

Findings of each of the engineers and metholodology used in each area is also outlined. Analysis of the effect of all the conservation measures is primarily covered in the Appendix.

The technical retrofit component of the project demanded most of the engineer's time and effort. Approximately one half million dollars of the special project grant was earmarked for technical modifications. Great use was made of historical utility bills to determine past energy use and profiles. A number of measuring instruments were available to the engineers to quantify various parameters in facility energy use. Analysis programs were available eventually on microcomputer to streamline many of the tedious calculations involved. A list of technical and operational recommendations was developed for each school.

Funding for technical measures came from the special project grant as well as from the department's B.Q.R.P. funding program. Conclusion from evaluation of the technical retrofits installed indicated that four typical modifications were applicable in most schools:

1. Setback of space temperature during unoccupied periods.

2. Shutdown of energy-using equipment that was not required during unoccupied hours.

3. Reduction in the amount of fresh air admitted and exhaust air expelled where possible.

4. Repair and upgrading of heating and ventilating control systems.

These measures tended to have reasonable capital costs and quick payback periods. Other modifications to heating and ventilating systems and electrical components tended to have longer paybacks. Upgrading of the building structure usually involved large capital costs with corresponding long payback periods.

A major finding during audits of each school was the great discrepancy between designed and actual operation of building systems. Technical retrofits could not be undertaken until "housekeeping" measures were first done to make systems operate as originally designed. This in itself often saved significant amounts of energy.

Technical modifications were always implemented keeping in mind that comfort levels and functionality of the space was maintained or improved. About one million dollars was spent in total on the technical component. Success of this effort has been confirmed through initial evaluation of subsequent facility energy use. Further monitoring of utility bills will be required, however, to calculate the total improvement in energy efficiency of each school.

The motivational component was a little harder to define and each engineer interpreted the scope differently. Typical activities included custodial training seminars, regular meetings with staff and informal contact with building users. It was found that if the communication flow was effective, school staff really did tend to act in more energy conserving ways. Other aids were used in making school staff aware of energy initiatives. Since the beginning of Phase II an Energy Conservation Quarterly newsletter has been sent to all school principals and school board administrators in the province. It has kept them updated on

project activities as well as explaining various aspects of energy conservation in school facilities.

Another motivation tool was the production of an audio-visual slide/tape presentation on the Phase II project. It explained in a very non-technical, people-oriented manner what the aims and activities of the project were. It was initially produced for showing to the public at the open-house showcase schools but has since been heavily used for presentation to many other groups.

Very little funding was devoted to the motivational component since it tends to be less capital intensive and more labor intensive. One main conclusion about this aspect was that support and cooperation from administrative decision makers and building operators was essential in ensuring an effective energy management program.

Another finding was that motivation could be sparked by the energy consultant during the project but continuation of a high level of motivation has to be the responsibility of the school board on a long term basis. The effect of motivation programs on the school occupants is discussed in the Stanley report.

The student involvement component primarily involved energy related activities for elementary level students and the use of energy conservation curriculum support materials for certain grades. The engineer served as a coordinator between the Energy Conservation Branch of Alberta Energy and Natural Resources and the teachers involved. This branch has personnel specialized in teaching energy conservation and producing curriculum support materials. They provided most of the manpower and expertise to implement this aspect of the project.

It was concluded that technically oriented engineers were not qualified or inclined to become directly involved in the curriculum area. This was better left to those in the academic field. It was also found that the elementary grades were the most receptive level at which to introduce energy conservation concepts. The curriculum guide for most elementary grades includes areas where introduction of energy conservation materials is appropriate. The effect of the student involvement program is discussed fully in the Stanley Associates report.

One important objective of the report is to correlate energy using factors with actual energy performance in schools. Much of the Appendix deals with school data and statistical analysis of this information.

One statistical analysis performed was an "Analysis of Variance". This type of analysis determines whether there is any significant correlation between a dependent factor and several independent factors. A number of combinations of one dependent variable and four independent variables was input for computer processing of data on the Phase II schools.

The dependent variables used were 1981 energy performance, 1980 natural gas consumption and 1981 natural gas consumption. Independent variables included:

1. Number of storeys

2. Wall construction (masonry, wood frame, etc.)

3. Building shape (compact, average, spreadout)

4. Maintenance level (good, average, poor)

5. Area in square meters

6. Heating degree days

7. Age of the original part of the school

8. Hours of occupancy

9. Grade level (elementary, junior, senior)

10. Heating system type (steam, hot water, forced air)

Results indicated that there was a close correlation between number of storeys, wall type, compactness and maintenance level versus resulting energy performance. Multiple storeys, walls accommodating a greater level of insulation, a compact building configuration and good maintenance all contributed toward better energy performance. Age, hours of occupancy, heating degree days and building area did not appear to correlate with energy performance.

It was also shown that number of storeys, compactness, building area, heating system type, maintenance level and heating degree days had a close correlation to resulting gas consumption. Building area and heating degree days would naturally be expected to determine natural gas consumption. However, it is not certain which heating system type resulted in the lowest gas consumption.

Conclusions from this statistical analysis indicate which inherent building characteristics seem to determine existing or potential energy performance. Some of these factors can be acted upon to upgrade performance, while others would only be practical to modify as part of a new school design. A larger sample size than fifty-two schools would be preferable in order to obtain more definitive information.

Indications from the Stanley Associates report were that the consulting services content and delivery to the schools were well received by the jurisdictions involved. The increase in awareness and adoption of improved attitudes toward energy use were evident from the survey of school and jurisdiction staff.

A number of teachers with help from Alberta Energy and Natural Resources either produced or made good use of conservation-oriented curriculum material. The special energy conservation activities organized in several schools were considered to be successful in involving students in the project.

The most effective technical measures in the context of Alberta schools were isolated. As well, the relative economic feasibility of modifications to structural, mechanical, electrical and operational components were clarified. This enables a priorizing of proposed measures that can be applied to schools in general.

While some of the measures were found to be easily applied by individual schools without outside help, many required an in-depth engineering analysis before being implemented. An in-house group of engineers providing this service proved to be practical and effective.

The proposed province-wide expansion of this project would be soundly based on experience and expertise gained by everyone concerned in the Phase II pilot project. It is an inevitable outgrowth of the commitment that Alberta Education has shown toward reducing energy use in schools.

1.0 Project Background

1.1 Baseline Studies

Since energy conservation programs were a relatively new idea back in 1977, it was obvious that a lot of research into the special problems facing schools in Alberta was necessary before the components for a province-wide conservation program were assembled. The Planning and Research Branch of Alberta Education contracts many studies on various aspects of education and school buildings to consulting firms.

As a result the Branch contracted with three different groups to undertake studies each on a different major aspect of conservation in schools:

1. Conservation through technical modification,
2. Conservation through energy-efficient new school design,
3. Conservation through no-cost operational strategies and staff motivation.

This was the beginning of Phase I.

1.1.1 Grande Prairie Study

This study originated with a decision by Alberta Education to fund a pilot energy conservation program in Grande Prairie School District No. 2357. It was specified that the study would centre on operational types of modifications to schools involving little or no capital expenditure, and a final report produced. The so-called "Grande Prairie Energy Management Project" was to explore the potential of energy management as an approach to conservation in schools.

Specifically, the Project team was asked to:

1. Assess energy use in the Grande Prairie schools.
2. Develop a management program to improve energy performance,
3. Implement, monitor and evaluate specific measures,
4. Estimate energy savings in other schools based on results from Grande Prairie facilities,
5. Integrate study results with concurrent studies on other aspects,
6. Prepare a report for distribution to school boards and other agencies.

The School Board sub-contracted the research to members of the Faculty of Environmental Design at the University of Calgary.

Part of the analysis of management was to work with the various levels of staff and administration to analyze their lines of communication and decide how best to reach them as far as energy use was concerned.

The problem of what measure of efficiency to use when quantifying energy use in schools was addressed. There are several possible options, including:

1. School system productivity versus energy use,
2. Efficiency of energy use starting at the building boundary,
3. Efficiency of energy use based on the point of resource extraction,
4. Life cycle energy demand of buildings.

Productivity can be measured as energy consumption per student, or energy used per square meter and square meter per student to take utilization capacity into account.

Life cycle energy use takes into account all the energy used through the lifetime of the building, including construction and demolition.

Results of the initial energy audits in the schools revealed that in most cases building construction was not suited to the local climate, interior comfort was poor, and energy efficiency and durability were not satisfactory. No specific set of building operating procedures had been set down.

It was observed that 50 percent of the average weekly electrical consumption (base load) is comprised of electric motors, which are not under the control of teachers and students. Lighting, accounting for the other 50 percent, is readily controlled by building users. This control effects lighting duration, not connected lighting power load. Students had the least effect on energy use since teachers and staff have authority.

The demands placed on equipment by building occupants certainly affect the levels of energy consumption throughout the year. Thermostat settings, light switching, operation of exhaust hoods and ceramic kilns are examples of this.

It was found that guidelines to reduce energy in buildings were readily available, but how to implement these steps was not discussed. Guidelines, for the most part, neglected the problem of how to ensure continuation of energy-conserving measures.

Since the study was commissioned to examine low or no cost measures to save energy, it followed that increasing productivity and the use of existing manpower was the route to follow in operating buildings more efficiently. Energy management involves people and their social, organizational, institutional and technical actions and interactions. An organizational approach to conservation means the organization that owns and maintains the facilities must be analyzed. Energy management must be a "grooming" function that continues year after year. One problem in raising the profile of conservation is that most school staff regard the maintenance function as a necessary appendage but not a direct concern of the administration.

If administrators give sound reasons for reducing energy usage, motivation of staff will develop through the existing management structure. Many principals, when queried, confirmed that they believed energy management should be a natural part of their administrative role. Their reward is the professional satisfaction of operating the school efficiently and displaying competent management practice.

Education of building users was addressed in that various staff must have conservation responsibilities written in their job description, and then they must be educated to handle these responsibilities. This would help ensure that success of the energy management program does not rely on particular personalities. By delegating specific responsibilities to staff, it is possible to judge whether individual responsibilities are being met. Channels of communication relating to energy management needs to be established or reinforced. Administrators must commend the efforts and achievements of subordinates.

As far as potential organizational problems relative to Energy Management, these seem to vary depending on the size and type of school system. Small systems often lack ready access to professional expertise, and large school divisions may not have good internal communications. Both hamper an Energy Management Program and indicate that different school systems would require different approaches to program consultation and implementation.

The information system is important, in that data on the energy consumption of buildings are critical in order to identify potential savings, plan strategies, regulate building operation, evaluate the conservation measures and motivate the facility users. This information feedback system must not be cumbersome.

Literature on motivation theory was reviewed to uncover maxims that apply to energy management. The following are examples:

1. Create a tendency to behave in a conserving manner that is stronger than the tendency to consume energy,
2. Reward and punishment systems leave the cause of the problem untouched,
3. When used, rewards must be significant, immediate and apparent,
4. Giving reasons to conserve attacks the cause of energy waste,
5. One must be convinced that energy waste is the problem and conservation is the solution,
6. It is known that people will not behave in a manner (such as an energy-wasting manner) that is shown to be inconsistent with their sense of identity, and
7. The individual requires feedback to control his or her use of energy.

In regard to the question of consultative assistance for school boards, it was concluded that:

1. Superintendents, who are not technical experts, need unbiased information on the condition and performance of the physical plant,

2. Local staff are generally not equipped to evaluate or implement energy management programs, and

3. In implementing a program, administrative, custodial and maintenance staff need specific guidance.

Because of the need for technical expertise to help school boards conduct an energy management program, a recommendation was made by this study. This was the provision of on-staff engineering expertise in Alberta Education to aid school systems province-wide. The great advantage of this approach was that the group developed would have a specific knowledge of energy use and organizational problems in schools. The group would need to be composed of professionals knowledgeable about buildings, environmental control, administration, conservation techniques, and public relations.

Detailed recommendations for good energy management arising from this study are listed in Appendix #1.

1.1.2 New School Design - Sweetgrass

This study was concerned with the use of standard building materials to construct a school with minimum energy consumption. Suggested energy performance standards have been set for buildings by various government levels:

1. Alberta Government suggested standard is 300 KWH/m^2 or 1080 MJ/m^2 per year.

2. Federal Government suggested standard is 250 KWH/m^2 or 900 MJ/m^2 per year.

The architect firm of Minsos Vaitkunas Jamieson was hired by the Edmonton Public School Board to design an energy efficient school. The Planning and Research Branch funded additional services from this firm to analyze the energy saving effect of various building configurations. Different combinations of building materials and systems were simulated using a special computer program to determine whether the resulting annual energy use fell within the standard. Seven comparisons were simulated:

1. different roof system types,
2. different wall construction types,
3. different wall heights,
4. different lighting layouts,
5. different window areas,
6. different mechanical systems, and
7. different supply air quantities.

The primary objective of the study was to determine whether schools could be designed within the energy standard and if so, which systems were required to attain this level. The possibility of earth-covered schools was not considered.

The simulated school model was a square 8 x 8 core school of 3067 square meters. There was an in-depth analysis of the performance of the building envelope, mechanical and electrical system efficiency, passive solar techniques and environment expectations of users.

Results of the computer simulation showed that the Federal target of 900 MJ/m^2 was a realistic goal. The increased capital costs arising from efficient design were well justified in a life cycle cost analysis. It was also concluded that systematic programs for maintenance and energy management are essential in maintaining the energy performance standard of a school.

It was found that to minimize the heat-losing surface area of the building, a square configuration was the most practical. A comparison with a number of existing schools indicated that they had an average area to perimeter enclosing wall ratio of 85 percent versus the 100 percent reference for a square.

Results of the computer simulation showed that a roof construction consisting of:

- gravel and felt roofing
- 102 mm polystyrene insulation
- 16 mm plywood
- 152 mm fibreglass batt insulation in 50 mm x 150 mm studs
- vapour barrier and fireguard
- roof beams...

was the most efficient design for energy use. The overall U-value was 0.338 W/m^2 K compared to 0.62 W/m^2 K for a standard roof design. Only one problem was anticipated, in the reduction of heat loss through the roof. Heat produced by people and lights would be excessive and not able to escape. This might necessitate artificial cooling, depending on the mechanical system used.

Results from the computer simulation showed that a wall section consisting of:

- 100 mm face brick
- 13 mm air space
- 38 mm polystyrene insulation
- 13 mm drywall sheathing
- 150 mm fibreglass batt insulation in 150 mm steel studs
- vapour barrier
- 13 mm drywall...

was the most energy-efficient wall design. The overall U-value was 0.19 W/m^2 K compared to a standard wall of 0.62 W/m^2 K. It was found that for a 65 percent reduction in the U-value, the total building energy use was down 12 percent and natural gas consumption alone was decreased by 15.4 percent.

The differences in wall mass between the various wall designs had no effect on energy consumption differences. Comparison of several simulated wall height designs indicated that 4267 mm was the most energy efficient. The standard school wall height is 3810 mm.

Several types of fluorescent lighting configurations were simulated, and a system using 2 lamp fixtures with 34 W tubes was the most efficient in using electrical energy. However, it caused a higher overall energy use because less heat was generated by the lighting, requiring more heat from the natural gas heating. This was considered a justifiable tradeoff because in a macro analysis (from the point of resource extraction), electrical power has an efficiency of 34 percent, while natural gas has 86 percent. Utility costs are less in this case.

Different glazing arrangements were also simulated. It was found that double-pane windows covering 30 percent of the wall area, particularly on the south exposure, was the most energy-conserving design. Triple glazing shows little or no improvement in efficiency. Artificial cooling might be required in warmer months using this design. The 30 percent figure is double the glazing area used in a present day standard school.

Several different mechanical system configurations were then simulated. The main conclusion was that all air heating and ventilation was less efficient than ventilation air coupled with perimeter radiation heating. Variable air volume (VAV) systems were found to consume less energy than constant volume. The most efficient system of those studied was a medium pressure VAV reheat system with perimeter radiation.

Finally, variations in the amount of ventilation air were simulated. It was found that odour control requires 1.0 m^3/ min. of fresh air and oxygen provision requires 0.11 m^3/min. of fresh air, so odour control requirements are the determining factor in minimum ventilation standards.

Several VAV systems with different CFM ratings were compared and it was found that for a simulated operation, in all cases the maximum air flow in operation was 60 percent of the design rating. To provide cooling supply air at 13 C, the optimum ventilation system capacity was 428 m^3/min.

When all the optimum component designs were combined, the following mechanical system configuration was simulated to determine energy usage:

A separate heating/ventilating unit for the gymnasium would use recirculated air at night. Ventilation for the rest of the school would be introduced through a VAV reheat system. This would make best use of internal heat gains, decreasing the energy used by fan motors. General heating would be provided by perimeter radiation. Ventilation fans would be shut down during unoccupied periods. The energy use breakdown follows:

1.	Heating, ventilating and lighting	160	KWH/m^2
2.	Incinerator or compactor	30	
3.	Domestic hot water	0.1	
4.	Car plugs (cycled)	7.3	
5.	Washroom exhaust fans	0.63	
6.	Kitchen ventilation	0.6	
7.	Other electrical equipment	0.75	

The total was 171 KWH/m^2/annum if a compactor was used, or 200 KWH/m^2/annum if an incinerator was used.

To maintain this energy efficiency in practice, good management and maintenance must be ensured. After a cost analysis, it was estimated that the increased cost of an efficient school was about 7 percent or $3.30/sq.ft. In 1977 energy costs, the payback is 10 years in energy saved. This would be lower in light of present 1982 energy costs.

1.1.3 Calgary Board of Education Study

This report was commissioned by Alberta Education in 1977 with the Facilities Department of the Calgary Board of Education. It incorporates a preliminary study conducted by Ried, Crowther and Partners on energy use in 5 existing schools, as well as a selection of conservation techniques in 2 schools. This study also deals with the installation of these retrofits and the evaluation of the selected modifications.

The Consultants were to undertake an energy audit of the building envelope, mechanical/electrical systems and plant operation, and propose modifications to improve energy use. They were to use computer simulations to model various retrofits on schools to estimate the energy savings.

Major simulated situations included additional insulation, reduction of window area, less lighting, reduction of ventilation rates, conversion to variable air volume, and night shutdown.

The Steering Committee for this study recommended the selection of cost effective and reasonably low cost modifications. Two schools would be retrofitted and would provide examples of possible practical techniques. It was desired to rank the possible modifications in order of greatest cost benefit.

Objectives set down for the study were:

1. Use computer simulations to model proposed modifications and estimate savings,
2. Select practical modifications that would apply to other schools as well,
3. Review operating strategies and personnel, compare actual energy performance with the simulated model, and
4. Contact other government departments for data and information exchange.

The energy audit portion of the study concerns itself with reconciling the energy input to the energy output of the building. The balance must be found between these.

One main conclusion of the analysis was that a single boiler plant is a major energy waster because it cannot match its output to the constantly changing load. Exhaust dampers were found to be very leaky, causing up to 30 percent induced air. Exhaust air was found to be a costly commodity and so it was worthwhile to minimize exhaust requirements.

The energy budget is considered to be the minimum utility consumption required to maintain a comfortable interior environment. It does not take into account "free" heat from solar and occupant gain.

The Facilities Department was cautious to avoid modifications that unduly complicated the control system. The effect of retrofits on other systems was considered and compliance with regulations was ensured.

Modifications actually installed in the two schools were:

1. Timer operated and dual speed exhaust fan control,
2. Fresh air dampers adjusted for minimum outside air,
3. Power burners proposed for boiler or staging using gas valves,
4. Door activated urinals, fans and lights in washrooms,
5. Night setback thermostats,
6. Discharge exhaust air through boiler room so cold air dump is reduced,
7. Weatherstrip outside doors,
8. Combustion air damper control,
9. Reduction of domestic hot water temperature to 43 C,
10. Removal of lamps and ballasts to reduce light level, and
11. Cover skylights and use fluorescents in skylights to maintain illumination.

Once installation was complete, a monitoring of consumption data would be done to determine actual energy savings. It was found to be very difficult to relate energy use to weather and occupancy variables. Relating weather effects through the spring season to energy use was difficult because of wind chill factors and solar gain.

For each installed or proposed modification, payback period and return of investment was calculated. As well, actual energy saved per year was estimated. These are listed in Appendix #3.

Recommendations for better energy usage included:

1. Instead of single boiler plants use extruded fin water tube multiple boilers,
2. Constant volume reheat with greater than 10 percent fresh air setting is inherently wasteful--use variable air ventilation with minimum fresh air,
3 Exhaust air should be used productively to pressurize the boiler room or temper the combustion air before being exhausted, and
4. More efficient lighting and better control methods should be used.

As well, it was emphasized that all components should be fully commissioned after construction to uncover deficiencies.

Several future trends were noted:

1. Closed loop heat pumps with solar assist and extended heat storage will be used,
2. More emphasis on renewable energy, such as solar and hydro power, less on gas and oil,
3. More envelope insulation and better site orientation,
4. Modular construction allowing for changing demands,
5. Lighting improvements in efficiency and quality,
6. More specific and realistic standards for fresh air, humidity and temperature,
7. More use of computer simulations and computerized building control,
8. Heat exchange systems,
9. Thermographic scanning of buildings,
10. More use of motion detectors against vandalism, and
11. Importance of preventative maintenance.

The zero base budget of energy for a building was also analyzed. This is the minimum energy required to maintain a reasonable environment during occupancy. Factors that affect this practical minimum are:

1. Cool-down and warm-up from unoccupied hours,
2. Sensitivity to cooling by furniture around the perimeter,
3. Condensation on interior surfaces, and
4. Likelihood of equipment or pipe freeze-up.

1.2 Significance of Study Findings

All three of the Phase I studies tended to overlap in their coverage of specific aspects of energy conservation and energy management in schools. This is natural, because it is impossible to isolate the factors relating to technical retrofits, operational strategies, personnel motivation and energy-efficient school design. These three studies and their associated reports provided invaluable information and conclusions about the specific problems in building and operating schools in Alberta.

Reports and guidelines produced in other provinces or countries are useful in a general sense, but techniques may not be applicable or justifiable in light of the climate we experience and our relative energy costs.

Therefore, it is preferable to develop preliminary findings and guidelines in small test groups of schools in various locales. Hopefully these will generate information applicable to the majority of schools in the province. There were a few observations and conclusions in one study that differed from that in another study, but this was probably due to different angles of attack and the particular situation.

The Calgary Board of Education report concluded that there were a number of cost-effective but not costly conservation techniques that worked in their two subject schools. The subject schools were chosen because they were fairly representative of a number of schools in Calgary. As a result, the list of suggested techniques should apply reasonably well to most of their stock.

This study found that tools such as computerized building simulations and analysis of historical consumption data were essential in estimating energy savings of various retrofits and determining actual savings in operation. The researchers were hampered by lack of time in which to evaluate the various installed measures, so many cost effectiveness figures still remained as estimates. The list of payback period estimates on various retrofits also indicate that one must consider the remaining life of the building before installing a modification of similar payback time.

The Grande Prairie study uncovered some interesting information and experience related to the human part of energy management. Their mandate was to explore the area of energy use improvement that is not capital intensive. This divides into two main areas: revision of operating strategies in a building, and education and motivation of building users to behave in an energy-conserving manner.

Part of the study was concerned with determining the major factors affecting energy use in a school. It was concluded that natural gas consumption due to exterior temperature was the major factor and that the usage and demands by building occupants were the next greatest factor. The exact relationship between gas consumption and temperature variation was hard to tie down to a graphical or formulaic presentation.

The reason for attempting to correlate climatic factors with annual energy consumption profiles was to come up with a method of setting expectable performance targets on these schools. Because of the lack of information on energy performance of schools in other areas of the province, it was difficult to obtain even comparative data. If one could isolate the factors affecting energy consumption that depend on occupant behaviour and demands, one might have some idea of the potential improvement in efficiency by changing user behavior.

Despite the resultant lack of hard data on the human element in energy efficiency, the general consensus was that an energy management program offered a sizeable savings in energy costs. Potential stumbing blocks in this approach include organizational problems in energy management, lack of technical expertise and a lack of communication between different groups involved.

It was strongly recommended by the Phase 1 studies that Alberta Education set up an energy consulting group to aid schools province-wide. The service would help implement energy conservation techniques and provide continuity in this program.

Actual data from two years of operation of Sweetgrass school confirmed the expectations of energy performance expressed in the original study. Computerized building simulations were used extensively to model various design options for this school and determine the most energy saving and cost effective measures to use.

Part of the study involved simulating two existing schools to calculate the theoretical energy usage per year. When annual consumption figures from the computer were compared with those from actual utility bills, the correlation was not very good. There were several reasons given for this, but it seems to indicate that computer building simulations are not as useful for calculating expected energy consumption figures as they are for modelling various design options and comparing the relative energy usage of each alternative.

Another major finding of the Sweetgrass study was that a school could be constructed within the energy budget of 900 MJ/m^2, as suggested by the Federal government. In addition, meeting this standard would impose only modest increases (perhaps 5-10%) on the capital cost. These increased initial costs would be easily justified over the life of the building if based on a life cycle costing analysis.

The report indicated that a school can be built which consumes one-third to one-half the energy of a similar-sized existing school. A number of the measures in the Sweetgrass design would be impossible to incorporate as a retrofit to an existing school, but others could be incorporated with little difficulty. It was stressed that an energy performance target can only be met and maintained in practice if the building is operated correctly and users are conscientious in their behavior.

From an overall viewpoint, the experiences and findings from the Grande Prairie and Calgary studies expose design and operational shortcomings in schools. Many are common to the majority of schools in the province, while others may apply to a small number of buildings. One major benefit of these findings was that steps could be taken to minimize the chance of these inferior design components or operating strategies from reoccurring in subsequent new design.

1.3 Building Quality Restoration Program and Guidelines Development

At the time the three studies were coming to an end, the Planning and Research Branch of Alberta Education collected the recommendations and guidelines from the three sources and brought them together into a publication called "Guidelines for Conserving Energy in Alberta Schools."

This publication began by listing the preliminary findings from each study, then explained energy budgets, audits and economics. Human management and operational strategies were then discussed, followed by specific technical measures applicable in schools. This was followed by a set of guidelines related to new school design, and means of evaluating a conservation program.

It was written specifically for distribution to all school systems in the province for their use. The Department hoped that these groups, using the publication as a handbook, could embark on an energy audit, set up a management program, select technical retrofits and evaluate the results of their efforts.

Since a number of the points and guidelines did not require in-depth technical knowledge of the school building, it was felt that school board staff would be capable of setting up programs on their own. They might require some outside technical aid to choose and design retrofit measures, but this should not be too difficult for them.

The present Building Quality Restoration Program (or B.Q.R.P.), was instituted in 1979 as a method of helping school districts to upgrade their buildings to suitable standards.

The whole idea of B.Q.R.P. started in 1965 with a study which was commissioned to investigate the current state of school construction and maintenance. Among other recommendations, the Badun Report, as it was called, stated the need for:

1. a clerk of the works to supervise school construction, and

2. a group in the School Buildings Branch to check blueprints, and have consultative services available to school boards regarding building maintenance.

It was felt that these recommendations would aid in ensuring that schools would be well constructed and suitable for the local needs, as well as improving the maintenance and appearance of the buildings. Consulting and checking services were set up in the School Buildings Branch, but school boards complained that they lacked the funding to upgrade their facilities.

In 1974, a B.Q.R. Program of one year's duration was set up in response to these needs. Funding for specified types of building and systems upgrading was available from the government for approved proposals from school boards. Over the next few years, the Program was extended in scope as well as funding. In 1979, a 5-year B.Q.R. Program was set up with $95.5 million and five inspectors to administer the distribution of this financial support.

Also proposed in 1978 and included in the Building Quality Restoration Program was the modernization component. The rationale for this was: "In view of the high cost of new school construction, declining enrolments and good condition of many older schools, this program should attract school boards to modernize existing good structures to meet the needs of present school programs." It attempts to reconcile the existence of an older, under-utilized school to the present and future needs of the community.

Additional categories adopted in 1979 were the Energy Conservation component, code requirements upgrading, and vocational equipment replacement.

Part of the Building Quality Restoration guidelines, then, are concerned with upgrading of systems for energy conservation. Any school board proposing modifications to schools under the guidelines may receive up to 80 percent support for the approved project cost.

The guidelines relating to energy conservation are shown in Appendix #4. There is no specific total budget allotted in the Building Quality Restoration Program for conservation items, as support for conservation-related submissions comes from the general fund. This support for conservation projects extends for the duration of the present 5-year Building Quality Restoration Program ending in 1983.

In general, the supported energy conservation items in the Building Quality Restoration Program guidelines represent measures that are tried and tested. That is, they have been proven to reduce energy consumption and to provide a reasonable payback on investment. As well, they have been proven to be practical in the organizational and the operational framework of a typical school building.

The newly-expanded Building Quality Restoration Program guidelines were expected to be an inducement for school boards to use the support available for conservation-related retrofits. The building and equipment modifications covered in the Building Quality Restoration Program guidelines were relatively simple, and it was assumed they would be implemented with little technical guidance. Results fell far short of expectations--there was little use made of guidelines and minimal Building Quality Restoration Program support was accessed.

After much discussion and analysis of the situation, it was decided to follow a recommendation put forth by the Grande Prairie study. This recommendation involved setting up engineering staff to undertake a conservation program in selected schools for a set time duration.

1.4 Follow Up Studies

The Sweetgrass school design involved the generation of an expected energy efficiency based on the computerized building simulation analysis. This performance figure could only be verified by observing the building operation and energy usage over one or two years. Edmonton Public School Board maintenance personnel monitored the operation for two years to study the effectiveness of the efficient mechanical systems and building envelope. A report was written outlining operational problems, environmental conditions and actual energy efficiency. This report is summarized in Appendix #2.

2.0 Design and Development of the Pilot Project

2.1 Purpose and Objectives

This new phase was to be "experimental" in that a relatively small number of "pilot" schools would become involved. An engineer would analyze the schools in great detail and do as much as possible to improve the energy efficiency of each building.

It was felt that the selected schools should cover a wide variety of provincial locations and climatic zones. The climate is significantly different between the Peace River country and Lethbridge, for instance.

The number of selected schools in each geographic area should be large enough to form a credible data base and provide a sufficent variety of structures to represent most school types in Alberta.

If a full fledged conservation program was instituted in a number of schools representing the majority of types encountered in the province, the results could be extrapolated to all other schools. The deficiencies uncovered in structures, equipment and operation would likely be common to a great many other facilities.

While organization and methods of running schools would vary from district to district, there are similar problems in operating facilities energy efficiently.

Since it was desired that school jurisdictions make use of the publication "Guidelines for Energy Conservation in Alberta Schools", one of the objectives of this second phase was to test whether the guidelines were practical, realistic and economically justifiable.

One of the complaints in the Grande Prairie study was that there was little or no data on energy performance of schools in various locations in the province. In answer to this, another objective set down was to calculate energy efficiency of selected schools in various locations to form a data base of anticipated performance figures.

Still another concern voiced in two of the studies was that the conservation efforts in a school need to be publicized to the community at large.

The success of this approach has been demonstrated in other cases where governments wished to influence a large number of people to gain acceptance of a program. If a few pilot projects were initiated and proven to be successful, surrounding areas would be encouraged to try it themselves. It was found to be a superior method compared to a large scale project affecting all intended recipients from the beginning.

This latter approach would often be perceived as government interference on a large scale, an explicit attempt to change people's attitudes. To minimize the likelihood of this effect, another Department of Education objective was to choose "showcase" schools from among the selected project schools. These schools would be open to the public and surrounding school jurisdictions at some point to demonstrate the success of the technical retrofits and motivational programs instituted there. This would encourage other school boards to initiate their own programs.

2.2 Resources Available

Now that objectives had been set down for this proposed Phase II to follow up on guidelines generated from the Phase I studies, resources had to be committed.

Once the plan took on a general shape, application was made to the Cabinet for a special grant to cover the administration and some capital funding. This was approved and an amount of $437,000.00 was appropriated to Vote 2, Grants to Schools, for the fiscal year of 1980-1981. An additional $150,000.00 was available for the following year of 1981-1982.

This amount was calculated by assuming an average grant per school of $10,000.00 for capital retrofits, and $1,700.00 for measuring instruments, motivational materials and administration. If five separate zones were chosen, this would amount to about $117,000.00 per zone from the appropriation.

In addition to this grant, the Department had to commit funds for the salaries and expenses of a project director and five regional energy consultants for the two-year project duration.

Education Minister David King announced the Phase II plan and its purpose in August of 1979. A grand total of $910,000.00 was made available for this project, which was to begin June, 1980, and end June, 1982. School jurisdictions were invited to submit proposals to become part of the group of schools selected for this pilot project by April of 1980. Specifics on funding amounts for each jurisdiction are listed in Appendix #11.

In addition to the special grant to fund this project, money was also available in the form of Building Quality Restoration Program support for conservation measures in schools.

There was also an advisory commitment made to the project in the form of a proposed steering committee. Mr. L. Hill, of the Planning and Research Branch, had been involved in the funding of the three Phase I studies and in getting the budget appropriation for Phase II. He became the Chairman of a committee that would be formed of members of various government departments, utilities and educational associations. The branch designated to implement the Phase II Project was School Buildings, represented by W. Hathaway.

Since five zones were chosen, the manpower had to cover all areas. It was desired that this field staff live and work in the zone rather than be based in Edmonton. The type of work required expertise on the level of an engineer, so an engineer was proposed to work in each area, supervised by a senior level engineer called a Project Director.

The steering committee members would meet periodically to discuss the progress of the project, and to provide direction and advice on how best to implement the plan. This financial and manpower commitment represents the input by Alberta Education to the project.

In addition, the school boards that would become involved in the project were expected to provide a reasonable amount of commitment. This included manpower, clerical help and office space as well as the possibility of spending some of their budget on conservation measures.

2.3 Implementation Plan

2.3.1 Call for Proposals

The project Steering Committee that had been formed met to discuss preliminaries in February of 1980. Dr. Hathaway explained the Phase I background to the present project and the function the Steering Committee was to perform. An advertisement to attract a Project Director had not been very successful due to the salary range of the Engineer III designation.

Once a Project Director had been hired it was decided that school boards would be notified that they could apply for inclusion in the project. Alternatives for the staffing of the project were discussed in case normal hiring did not produce satisfactory results.

The notification to school boards about the project was to be handled as a "Request for Proposal" or R.F.P.

An executive Steering Committee meeting held in May, 1980 decided on several criteria that school boards must meet if they wanted to become part of the pilot project.

1. Moral commitment of the energy coordinator supplied by the school board was important. As well, they had to be prepared to supply office space, staff assistance, some local funding, and an ability to handle the budgeting associated with the project.

2. Access to facilities for showcase purposes, entry into the curriculum and ease of travel from Edmonton was important.

3. Weather data must be available either through a local airport or Environment Canada.

4. School density was a consideration in that the buildings should not be dispersed too widely.

In May, 1980, R.F.P. forms were sent to all school boards and it was planned that one submission from each of the five geographic/climatic zones would be chosen. Response to this invitation was not overwhelming and the department had to offer more encouragement to those who were hesitant to commit themselves. There were concerns by some potential boards that there might not be sufficient returns to justify the commitment expected of them.

A proposal to become part of the pilot project was received by the Medicine Hat School District No. 76 in May, 1980. They had already taken some steps to follow the Conservation Guidelines after forming an ad hoc Energy Committee. The district was eager to commit ten of their schools and accommodate the other requests in the R.F.P.

Also in May, 1980, a proposal was received from Fairview School Division No. 50. They wished to have their nine schools included in the project and were willing to comply with the conditions of the R.F.P.

A proposal was received from the Edmonton Separate School Board in June, 1980. They were willing to commit ten of their schools, plus the assistance of a number of their operating and maintenance people. It was noted, however, that funding from the school board would be minimal in fiscal year 1981 because of the timing of the R.F.P. Support could be provided for in the budgeting for the next fiscal year.

By late in June, the list of school boards answering the R.F.P. had expanded to one or more in each of the five climatic zones:

Zone 1 - Fairview School Division No. 50 - five schools
- St. Thomas More R.C.S.S. District No. 35 - one school
- Peace River School Division No. 10 - four schools

Zone 2 - Lakeland R.C.S.S. District No. 150 - two schools
- Lakeland School District No. 5460 - eight schools

Zone 3 - Edmonton R.C.S.S. District No. 7 - ten schools

Zone 4 - Rocky View School Division No. 41 - eleven schools

Zone 5 - Medicine Hat School District No. 76 - ten schools

In many cases, these participating jurisdictions were hesitant to commit themselves because of the risks involved in being part of a pilot project. There was no guarantee that this experimental phase would produce the results claimed by the Phase I studies or by the published Conservation Guidelines.

2.3.2 Evaluation/Selection Criteria

In the planning stages, it was decided that certain criteria would be considered to select which school board applications would be accepted. The main criteria were:

1. Compliance with the requirements set down in the R.F.P.

2. Representative of one of the five climate zones in the province

3. Suitability of the jurisdiction for providing pilot schools

Choice of sites within each zone was proposed according to the following factors:

1. Nature of building structure

2. Average condition of upkeep

3. Ease of project administration

However, at one of the Steering Committee meetings it was pointed out that it might be counterproductive to include only well kept schools. A variety should be included, from older to newer, and from poorly maintained to spotless types.

SELECTION OF SITES

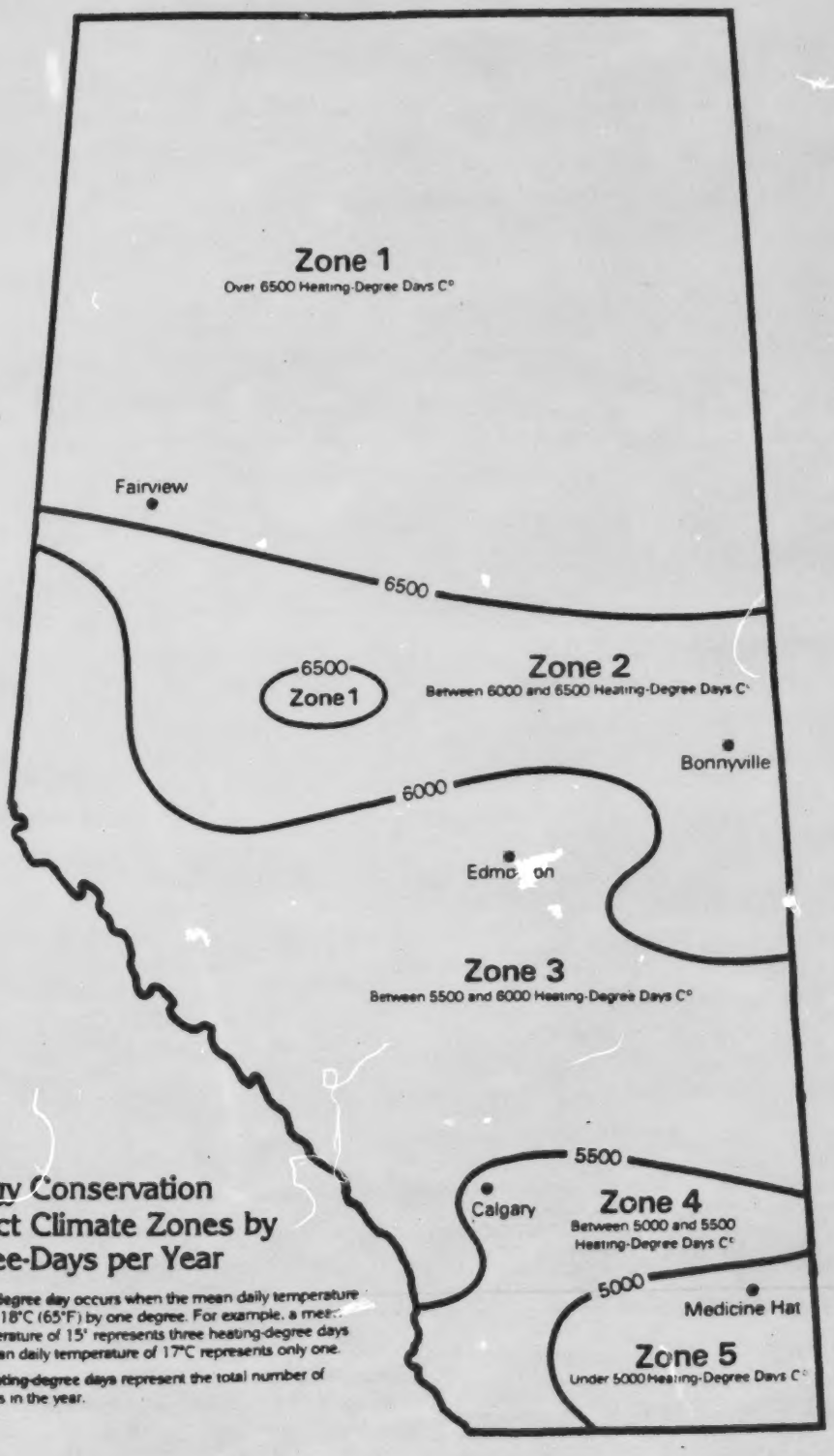

Zone 1
Over 6500 Heating-Degree Days C°
Fairview
6500
6500
Zone 1
Zone 2
Between 6000 and 6500 Heating-Degree Days C°
Bonnyville
6000
Edmonton
Zone 3
Between 5500 and 6000 Heating-Degree Days C°
5500
Calgary
Zone 4
Between 5000 and 5500
Heating-Degree Days C°
5000
Medicine Hat
Zone 5
Under 5000 Heating-Degree Days C°
Energy Conservation
Project Climate Zones by
Degree-Days per Year
A heating-degree day occurs when the mean daily temperature falls below 18°C (65°F) by one degree. For example, a mean daily temperature of 15° represents three heating-degree days while a mean daily temperature of 17°C represents only one.
Annual heating-degree days represent the total number of degree-days in the year.

FIGURE #1

2.4 Selection of Sites

2.4.1 Zone Geographic Characteristics

Geographically and climatically the pilot project school locations are unique. School names and locations are listed in Appendix #6 and zone climate factors are outlined in Appendix #5.

Zone 1
Relative Location in Alberta

The Zone 1 Project Schools are all located near latitude 56°N in a rich agricultural belt north of the Peace River.

Geographic Features

With the exception of the thousand-foot canyon of the Peace River, incised into the farmland, the surrounding plateau is flat with a very slight incline towards the river. Because of low altitude, the shallow angle of the sun in summer and its almost circular path, portions of this northern region experience unique microclimates, comparable with or superior to climates much farther south. Long hours of daylight in the valley bottom cause very high summer temperatures, averaging 6 F. higher than the plateau above. During the heating season, the valley bottom is subject to advection frosts and averages a few degrees cooler than the upland. Most of the outskirts of the small rural towns are exposed to wind, and it is here that most of the schools are located.

School Board Administration

The three school boards were each made up of a superintendent and secretary-treasurer with support staff and few maintenance staff.

School Population

The small towns in the region have shown sharp increases in population over the last 10 years owing to increased economic activity in the towns. Rural population is more stable, exhibiting moderate growth as young families raise children, or new land is occupied, broken and turned over to cultivation.

General Characteristics of Population

The population is a very mixed group of largely second and third generation immigrant families from Germany, Eastern Europe, the Ukraine and the British Isles. Farm families tend to be large, but not all children complete secondary education. Many families still use English to communicate with the outside world but their own language at home.

Mechanical System Types

Most school heating systems use some variation on natural gas-fired forced air furnaces. Larger schools of Peace River School Division use steam and hot water boilers with unit ventilators in classrooms and a reheat coil for the gymnasium heat. Fairview School Division No. 50 and St. Thomas More Roman Catholic Separate School District No. 35 operate only one hot water boiler a piece.

Availability of Contractors

Grande Prairie and Peace River support a variety of contractors and availability in either area poses no problem. Fairview, on the other hand, supports only one plumbing and heating contractor. Specialized contractors are not available in this area.

Zone 2

Relative Location in Alberta

The Lakeland School Districts are about 240 km northeast of Edmonton in an area referred to as the Lakeland. Close to the Saskatchewan border, the main features of the region are the Cold Lake Air Force Base and the Esso heavy oil pilot project.

Geographical Features

The area has a high concentration of lakes, the largest being Cold Lake. Except for a few river valleys the terrain is predominantly level to slightly rolling. The region sits on the Athabasca Tar Sands which contain great reserves of non-conventional crude oil. Much of the land has been cleared for agriculture.

School Population

Student population was stable from 1977 to 1980 but declined in 1981. Students are also transferring from one school to another within the district. The cause of declining enrolment stems from the uncertain economic climate in the region.

General Characteristics of the Population

The four main ethnic backgrounds are English, French, Ukrainian and Native. Major occupations include farming, construction, petroleum, civil service and tourism. The military base is the largest single employer.

School Board Administration

In 1980 a reorganization of school jurisdictions occurred as a result of the Sage Institute Report "The Future of Education in the Bonnyville/Cold Lake/Grand Centre Area of Alberta".

The existing jurisdictions were dissolved and new trustees elected to form an essentially new pair of boards. The administration consists of a superintendent, secretary-treasurer and support staff.

Technical Staff in Board

Technical staff is very limited. The Public District has a maintenance supervisor with a staff of four but any specialized repairs are given to outside contractors. Lakeland Separate has no maintenance staff and contracts out for maintenance and repair as required. There is a building project manager whose main responsibilities are new construction, renovations and BQRP projects.

Mechanical System Types

The predominant heating and ventilating equipment is natural gas fired forced air units. There are also hot water heating systems with central fan ventilation units.

Availability of Contractors

There are plenty of the common trades such as electrical, plumbing, roofing and glazing contractors. Because of the state of the economy, bidding was quite competitive. More specialized services such as automatic controls, boiler analysis and infra-red scanning are not available locally.

Zone 3

Relative Location in Alberta

The Edmonton RCSS District, in greater Edmonton, is within this zone.

Geographical Features

The city is composed of flat or gently rolling terrain. The North Saskatchewan river cuts through the city in a deep valley. The climate is cold and affected slightly by chinooks.

School Population

Student population growing rapidly but there is a shift from the older inner city schools to newer suburban facilities.

General Characteristics of Population

Great variety of occupations in the city with the socio-economic level range from low to moderately high.

School Board Administration

The board administration consists of a superintendent and two deputy superintendents, one for facilities and planning and the other for administration. There is a sizeable maintenance and construction staff as well.

Technical Staff in Board

No engineers on staff but maintenance staff includes capable personnel from all trades.

Mechanical System Types

The most predominant heating systems are hot water or steam boilers.

Most ventilation is accomplished using central mixed air fan systems.

Availability of Contractors

Contractors of all types, including specialized services, are readily available.

Zone 4

Relative Location in Alberta

This zone is within the Rocky View School Division, located in southern Alberta, bounding the City of Calgary on the north, west and east.

Geographical Features

The topography ranges from thickly wooded foothills in the west to sparsely treed prairie in the east of the zone. Lakes are small, with most water being carried by the Bow and Elbow rivers. The climate is classed as cold temperature, modified by chinooks.

School Population

Zone 4 is experiencing the largest growth rate in the province, at 20% per year. An average of two new schools a year are being built to handle the influx.

General Characteristics of Population

The towns of Cochrane and Airdrie, plus the communities of Springbank and Chestermere, largely serve as "bedroom communities" to Calgary, although Cochrane and Airdrie do have their own commercial and industrial bases. The more rural communities, such as Beiseker and Crossfield, tend to have a larger population of farmers and ranchers. Wealthy executives tend to escape the bustle of Calgary and settle on acreages around Springbank.

School Board Administration

The board administration is composed of a superintendent and secretary-treasurer and sizeable support staff. Meetings are held twice monthly.

Technical Staff in Board

There were no engineers on staff; however, the maintenance staff consists of several fairly knowledgeable people.

Mechanical System Types

The most predominant heating type is hot water heating using radiators, followed by hot air furnaces and steam heating.

The common ventilation system is exhaust fans in the older schools, with central air handling systems used in the newer schools.

Availability of Contractors

Due to the proximity to Calgary, getting contractors is no problem. However, due to the booming economy, delays in getting work done is common, as most contractors are very busy.

Zone 5

Relative Location in Alberta

This zone, comprising Medicine Hat School District No. 76, is located within the city of Medicine Hat in southeastern Alberta.

Geographical Features

The topography is dry flat prairie, with few lakes and the South Saskatchewan River valley. The climate is classed as cold temperature modified by chinooks.

School Population

The school district student population is stable with some growth expected.

General Characteristics of Population

The population is primarily urban, based upon manufacturing, oil, gas and agriculture. The surrounding area consists of farmers and ranchers.

School Board Administration

The board administration is composed of a superintendent and secretary-treasurer and support staff. The board meets twice monthly.

Technical Staff in Board

The school district has a facilities planner and an adequate maintenance staff.

Mechanical System Types

The predominant heating systems are hot water radiation, followed by steam radiation and then hot air.

Ventilation systems are exhaust fans in the older schools and secondly mixed central fan air systems in the newer buildings. Some schools have mechanical cooling as well.

Availability of Contractors

Contractors for all retrofit projects are readily available in the local area.

2.5 Project Organization

2.5.1 Steering Committee

As with any experimental type of project, a group of knowledgeable people not directly involved in the project is needed to provide guidance.

In the early stages of the formulation of the Phase II project, it was decided to set up a steering committee that would meet periodically for the duration of the project. They would review progress, discuss problems in implementation, and offer advice on ways to overcome obstacles.

In November of 1979, a list of members was proposed and they were asked to form a Steering Committee. They included representatives from other government departments, education organizations and utilities per the following list:

W. L. Hill	- Planning and Research Branch, Alberta Education
W. Ede	- Field Services Branch, Alberta Education
W. Hathaway	- School Buildings Branch, Alberta Education
I. Burn	- Alberta Energy and Natural Resources
M. Holt	- Alberta Housing and Public Works
R. B. Smith	- Alberta Government Services
B. Hiron	- Edmonton Power
M. Salm	- Northwestern Utilities
C. Rea	- Alberta School Trustees' Association
W. Hughes	- Alberta Teachers' Association

From this group, four members were chosen to form an Executive Steering Committee:

W. L. Hill
W. Ede
W. Hathaway
M. Holt (replaced by M. Johnson)

The first Steering Committee meeting was held in February of 1980. Each member was sent an information package to explain the purpose of the project.

Dr. Hathaway explained at the meeting what efforts were already underway. Hiring of engineering staff was discussed, as well as selection of participating school jurisdictions. It was decided that the Executive Committee would oversee the administration and on-going evaluation and make recommendations on major directions to be taken by the project. The Steering Committee would discuss and approve these recommendations.

The Steering Committee was scheduled to meet every three to six months. A list of items for each meeting, assuming the project stayed on schedule was drawn up as follows:

June 1980	- review of project scope, schedule, budget for participating jurisdictions, contractual obligations
December 1980	- review of progress, energy inventory, budget, audit statistics, retrofit recommendations and contracts with jurisdictions

April 1981 - review of project implementation, financial status, energy savings estimates

September 1981 - review of project accomplishments, contracting problems, evaluation procedures, public relations

January 1982 - review of evaluation statistics, final report outline, financial status and effect of project on school operations and energy use

June 1982 - review the final report, acknowledge all project participants and terminate the project

The Executive Committee was to meet every two to four months to review progress, redirect the project course if necessary, and prepare agenda items for discussion at the Steering Committee meetings.

2.5.2 Project Director

In February of 1980 the Steering Committee reviewed various options on staffing of engineers for the project. Preliminary indications were that it might be difficult to hire the five Engineer I-II's and one Engineer III due to the shortage of qualified people and the relatively low salaries offered.

Several options were put forward, including:

1. Seconding an engineer from elsewhere to serve as Project Director for two years.

2. Hiring a suitable engineer on staff.

3. Contracting a consulting firm to provide an engineer for the project. Dr. Hathaway would then become Project Supervisor.

The role of the Project Director was developed, and involved general administration, evaluation and supervision of the five field consultants. Specifically the duties included:

1. Preparing plans for implementing the 50-school energy project.

2. Developing Requests for Proposal to solicit participation of school jurisdictions in the project.

3. Administering the project.

4. Preparing reports, including the final evaluation report.

5. Designing procedures and training programs to undertake energy inventories.

6. Developing means of estimating target energy budgets for each school.

7. Developing methods and standards for conducting energy audits in each school.

8. Developing guidelines for recommendation of retrofits to correct for energy waste.

9. Developing means of evaluating the project both qualitatively and quantitatively.

10. Providing training and advice to energy consultants, educators and operating staff.

11. Developing standards of energy consumption for schools based on evaluation of energy reduction in the 50 schools.

12. Making recommendations for policies and guidelines for future conservation programs.

The Project Director, in effect, runs the day-to-day affairs regarding the project through the five consultants. He makes recommendations and reports to the Steering Committee and participates as a non-voting member.

2.5.3 Field Energy Consultants

At the February, 1980 Steering Committee meeting, it was recognized that there might be difficulty in hiring five level I-II Engineers on staff for a two-year period. Several options were discussed, including:

1. Recruitment of five engineers on staff if possible.

2. If three of five engineer positions were filled, no contracting of the other two would be done.

3. If the level I Engineers were hired, an additional equivalent full-time engineer might be contracted from a consulting firm.

It was realized that hiring of engineers would be most successful if new graduates were approached.

The role of each Energy Consultant was set down, covering inspection of facilities, and implementing technical and operational modifications in schools. The duties were to be as follows:

1. Collecting utility data to prepare energy inventories for each school.

2. Developing energy budgets based on existing energy performance and expectable improvements.

3. Conducting energy audits to uncover areas of energy waste.

4. Designing structural, mechanical and electrical system modifications with associated cost payback analysis.

5. Selecting and recommending the most suitable retrofits for consideration by the local Energy Conservation Committee.

6. Developing tendering specifications, helping the board in selecting tenders, and supervising installation of retrofits.

7. Implementing evaluation and training programs to prove and continue the effectiveness of the measures instituted.

8. Providing training to educators, operating staff and contractors.

9. Reviewing project evaluation and aiding in developing consumption standards for Alberta schools.

10. Preparing reports and progress statements as requested.

11. Making recommendations, based on experience gained in this project, for future conservation programs.

The field consultants were supposed to work continously within the school jurisdiction and discuss problems and progress with the Project Director as required. In effect, each consultant was "on his own," and not directly supervised.

2.5.4 Zone Energy Conservation Committees

One of the conditions set out by the department when asking for school jurisdictions to participate was that they form a local energy committee.

These committees are composed of one or more teachers, principals, operations people, secretary-treasurer, as well as the field energy consultant. Their mandate is to meet periodically to discuss progress and problems relating to the project in that jurisdiction, as well as discuss and approve recommendations made by the consultant on technical and operational modifications.

This local Energy Conservation Committee disburses the Energy Project funding from the department. They decide how much school board support will be supplied for various projects and they also provide a variety of viewpoints regarding conservation because of their different backgrounds.

It is hoped that after the two-year pilot project is completed, the conservation committees will continue to operate.

In this way, the success and viability of the energy management program can be maintained because there exists a group dedicated to its continuation.

3.0 DESIGN OF PROJECT STAGES

3.1 Inventory of Energy Consumption

One of the first activities that had to be undertaken once the energy consultants went to each zone was to gather old utility bills for each school.

It was decided that three years of historical natural gas and electrical utility figures would be necessary to give an idea of the annual energy use profile before efforts were made to reduce consumption.

The haphazard method of reading and estimating meters by the utility company sometimes leaves gaps so sufficient data must be available in order to detect anomalies.

The 24 months of electrical and gas consumption figures were to go on a special form for this purpose. These figures would then be converted to a common metric energy unit of megajoules.

Conversion for electrical consumption involves multiplying kilowatt hours by 3.6 to get megajoules. Natural gas conversion is a little more confusing, depending on the units used. Those billings in gigajoules (which is becoming the standard) involves multiplying the gigajoule figure by 1000 to get megajoules. Bills that are in units of therms must be multiplied by 105.5 to get megajoules. Units of M.C.F. are the most difficult to work with because they represent a volume of natural gas and not its heat content.

Natural gas, depending on the particular well and the time of year, has a variable heat content measured in B.T.U.'s per cubic foot. This content can vary from 950 to 1150 BTU's/CF and differ on each monthly bill. For project purposes, a single conversion factor of 1129 was decided upon, unless the actual conversion factor was known.

Once megajoule equivalents were calculated for electrical and gas consumption, they were combined into a total monthly megajoule figure. If one wanted to normalize this figure for school size, the total megajoules could be divided by the school's area in square meters.

From the time the consultant began work in each zone, the current utility bills were collected and recorded as they were received. In addition to this, it was planned to have the custodian read the school utility meters weekly as a more accurate method of monitoring and recording energy consumption.

In addition to tabulation of electrical and natural gas energy, water meters were to be read regularly. While the water consumption figures do not form part of the energy consumption, they are monitored because they are another natural resource that needs to be used wisely.

Specific rate schedules for several utilities are outlined in Appendix #12.

3.2 Energy Budgets

Using a minimum of twelve months of historical utility figures, one can calculate the energy performance in megajoules per square meter per annum ($MJ/m^2 \cdot a$).

This figure is considered to be the energy performance before any conservation measures have been implemented. Megajoules are divided by the building area to normalize this figure and provide comparison of different schools. The MJ/m^2 are calculated over twelve months to cancel out the seasonal profile of energy use and produce a trend indicative of energy efficiency.

Alberta Education, in its "Guidelines for Energy Conservation in Alberta Schools," suggest a target energy performance of 900 MJ/m^2/annum for new school buildings. Setting an energy budget means establishing a target figure to which the existing energy performance figure will hopefully be reduced.

The Alberta Education target is primarily meant for new school construction but is believed possible for many existing buildings. One may choose any target figure, but it should set a challenge for those involved in improving energy efficiency.

An energy budget may also be set after the energy audit, choice of retrofits and calculation of potential energy saved. This energy saved will translate to a new lower energy efficiency figure that can be used as the target performance for that school.

There is an expectation that the average school should be able to set a target and successfully reduce its energy use by 25 percent. In other words, the target figure can be set at 75 percent of the original performance figure for many school facilities.

Once a target has been set and all conservation measures are instituted, one must monitor the monthly consumption figures. A month by month rolling average ($MJ/m^2 \cdot a$) of energy performance is easily calculated. These month by month figures will indicate the trend in energy efficiency.

Because this performance figure requires twelve previous months of consumption amounts for its calculation, the effect of conservation will not be seen immediately. It may take twelve months of calculated performance figures to see the full effect of conservation and reach the expected target.

3.3 Energy Audits

At the beginning of the field project, a set of measuring instruments was supplied to each energy consultant. This set of equipment includes:

1. Amprobe AC volt-ammeter recorder
2. PTC portable recording thermometer
3. Simpson light illumination meter
4. Taylor sling psychrometer
5. Simpson multimeter
6. Amprobe clamp-on ammeter
7. Ideal receptable circuit analyzer
8. Kane May digital temperature indicator

Total cost for these instruments was approximately $2,000.00 per set. These instruments were to provide most of the information required by the consultants in the course of their audits. More sophisticated instruments such as thermographic and boiler efficiency meters would be used by contractors in the course of inspection contracts.

Mini-Audits

A mini-audit entails a general walk-through inspection of a school building. Usually, the principal, maintenance supervisor and caretaker would accompany the consultant.

This was designed to be one of the first activities the energy consultant would be involved in.

Overall condition of the walls, windows, and doors are observed. The types, quantity and capacities of boilers, pumps, fans and furnaces are recorded. The type of lighting and the impression of light quantity is noted. Normal hours of school operation including community use are estimated. Obvious problems with cracks, cold walls, constantly running fans, excess lighting and so on are recorded.

Operational problems with boilers, fans and heating units are also noted. Once the general impression of the school is gleaned by the consultant through observation, and problems are outlined by the other survey members, some simple recommendations are listed that would improve the deficiencies.

The mini-audit walk-through survey is primarily meant to be an orientation for the consultant. It also provides an opportunity for the other members to air their concerns regarding energy use or waste in the building.

No measuring instruments are used in this phase; just visual observation and discussion with building users. The audit is qualitative in its analysis to give the consultant an appreciation for the most likely areas to inspect further. A number of the simple recommendations would eventually be implemented and others might be modified after confirming or contradictory information is uncovered.

Results of the mini-audits in each school in each zone are forwarded to the Project Director. This gives him an idea of differing school system configurations and typical deficiencies in the facilities of each zone.

The data provided by this phase, as well as historical energy consumption figures, form the basis for all subsequent analysis of the school buildings. Details on the heating and ventilating systems in each school are listed in Appendix #8.

Maxi-Audits

The mini-audit was designed to be a short walk-through orientation of the facility layout, plant equipment and general building condition.

Once this step was complete, the detailed analysis of the school could begin. The term "maxi-audit" in this context is meant to convey the idea of a large scale study of the building and its operations.

The primary objective of the maxi-audit is to calculate all the heat losses and gains, and the energy consumed to make up for the heat loss and maintain the environment.

Once an energy balance, similar to a financial balance sheet, is produced, one can detect anomalies pointing to areas of energy waste. Many specific energy-wasting areas are obvious from visual inspection but often a continuous or intermittent loss of energy or heat is well hidden. This only surfaces in an energy balance analysis.

It was planned to have this energy balance done manually for each school by the consultants, but it is a task that would lend itself well to the use of microcomputers. A lot of tedious calculations are involved in developing an energy balance for a school.

A number of activities are involved in the maxi-audit, including the following:

1. Reading building blueprints to determine R-values of surfaces, routes of ducting and piping and design airflows to various areas.

2. Efficiency measurement of boilers using specialized monitoring instruments.

3. Infrared scans of exterior building surfaces to locate specific areas of heat loss.

4. Recording of mechanical and electrical equipment ratings and capacities.

5. Observation of occupied hours for various areas of the facility.

6. Close inspection of interior and exterior walls, roofs, windows, and doors.

7. Measurement of the daily or weekly electrical load profile using recording ammeters.

8. Calculation of number of occupants at different periods, solar energy entering the building and heat given off by lighting and equipment.

9. Estimates of infiltration heat losses through cracks and holes in the walls.

10. Measurement of illumination levels in various areas using a lightmeter.

11. Calculation of heat loss through individual surfaces and total heat loss.

12. Calculation of internal heat gain from "free" heat sources.

13. Development of energy balance model reconciling heat losses and "free" heat gains with primary energy required to maintain the building environment.

14. Discovery of specific causes of energy waste, and estimates of quantities of energy lost.

The units of energy losses, gains and primary energy consumed are standardized to the metric unit of megajoules or gigajoules.

It was expected that this phase would take about one week per school, with a large portion of the time devoted to manual calculation of the energy balance.

The information obtained from the maxi-audit and study of the historical utility data should be sufficient to determine the energy-using habits and deficient areas related to energy efficiency. The whole retrofit and operational modification program is based on this.

3.4 Design of Corrective Measures

3.4.1 Technical Modifications

It is recognized that there are three major factors relating to energy waste in the school--technical deficiencies, inefficient operating philosophy and strategy, and lack of energy conserving ethics on the part of the students and staff.

Perhaps the easiest to tackle is the problem of technical deficiencies. These can be remedied using money, good judgement and technical expertise. The other two factors are not as simple to rectify.

School buildings tend to be fairly simple entities from a mechanical engineering point of view. The technical improvements to particular systems or components also tend to be relatively uncomplicated.

Most of the recommendations that would arise from the auditing procedure involve simple modifications such as installation of a time clock to control fans, installation of setback thermostats connected to a central timer, or application of loose insulation to an attic. These types of retrofits do not require any extensive engineering design.

In most cases, the project can be described in several paragraphs accompanied by a school layout showing location of the retrofits for the purposes of Building Quality Restoration Program submission. As far as tendering the project, a single page description with sketches would be adequate for a bidder to understand the intent and scope of the work.

In other words, there are very few retrofits that would require full-fledged specifications and drawings. In cases where a more complicated retrofit was warranted, the energy consultant might have to contract the design out to a sub-consultant. The concept of the retrofits in most of the schools is straightforward, but it is the implementation that can cause problems. Many contractors are unfamiliar with time clocks, setback thermostats and simple load controllers.

It is incumbent on the energy consultant to maintain close supervision at the installation stage, because the actual work can become complicated.

3.4.2 People Management

Improvements to staff management and operational strategies pose quite a different problem perhaps more suited to consideration by a psychologist. The energy consultant becomes familiar in time with the particular staff in each school and their philosophies that impact on building energy use. He has to analyse their operation and decide what changes in operation could be made without affecting the users. In some cases, it might involve compromise between the staff's habits and increased energy waste.

Changes in plant operation are mainly related to the methods that the custodian uses to keep the heating and ventilating systems operating. As such, the emphasis would be on educating and motivating the custodian to change from the previous energy-wasteful modes of operating the plant. The principal or maintenance supervisor who exerts the greatest control over the custodian would also have to be dealt with.

The rest of the staff, teachers and administrative personnel, are the building users who have the greatest effect on school energy use apart from the custodian. For this group, it is a matter of educating and motivating to let them know the effect of leaving lights on, doors open, or coming in alone on weekends to work.

Usually, the advice will have the most effect if the principal puts his/her full support behind the recommended changes in habits. The principal has to be convinced of the effect of staff on energy use and the need for improvements in everyday operation. These general guidelines related to management may cover a large number of separate activities calculated to promote the human factor in energy efficiency.

3.4.3 Curriculum/Student Involvement

Curriculum, or student involvement, is the third area that must be attacked to provide a complete approach to energy management. This is considered to have the most profitable long term results if applied successfully. Because of the energy consultants' qualifications and time constraints, the promotion of student involvement is in many ways beyond their scope.

The challenge of student involvement is recognizing the information needs of the various grade levels and providing appropriate materials and activities for these student groups. It is believed that the most promising level of students at which to promote curriculum activities is the elementary level. There are a number of sources of energy conservation-related curriculum material for different grade levels. As well, Alberta Energy and Natural Resources has a branch equipped to provide curriculum kits and field visitation to schools requesting this service.

It is up to the energy consultant to promote these services and sources of material to the teachers and students he is in contact with in the project schools. He may also act as a coordinator to arrange meetings between curriculum consultants and groups of teachers.

3.5 Selection of Corrective Measures

The mini- and maxi-audits provide the information required to find specific areas of energy waste. The consultant, using his knowledge and experience, suggests alternative methods to rectify these problems individually or collectively. The proposed solutions to these technical deficiencies have to meet a set of criteria to be considered as part of the retrofit program:

1. They should preferably be eligible for funding support under the Building Quality Restoration Program but this is not essential.

2. The change should either maintain or improve comfort conditions in the school.

3. The payback using life cycle costing methods should be less than five years.

4. The technical retrofit should be simple enough for a local contractor to do the installation.

5. The modification should be simple enough for a caretaker to operate and maintain, but not necessarily repair.

Once the recommendations on retrofits and their alternates were put together by the consultant, the proposal would be discussed with the energy conservation committee. The committee would discuss the pros and cons of the various retrofits and alternatives and decide which ones to proceed with. Application could then begin for those projects eligible for support under the Building Quality Restoration Program.

For those not eligible for Building Quality Restoration Program support, a combination of Energy Project funding and school board support would have to be considered. The average project funding per school was calculated to be about $10,000.00 and it was planned to use this as equitably as possible among schools. However, the particular needs for technical upgrading in each facility determine its financial requirement. As a result, it might be necessary to apply substantially more funding for projects in one school than another. It would reflect the best use of available money for energy saved.

3.6 Installation of Technical Retrofits

"Installation" refers primarily to the technical modifications to mechanical, electrical and structural systems. Once projects eligible for Building Quality Restoration Program support are approved for project funding, tendering of the work can begin. Because most of the retrofit projects are simple from an engineering point of view, formal specifications and drawings are not usually required. A one-page written description of the work required and a sketch showing locations of modifications are sufficient. Tender forms would be sent to local and out-of-town contractors to try to get the most competitive prices. The energy consultant would be available during the bidding process to answer any questions they might have about the work to be done.

No projects would be tendered or started before Building Quality Restoration Program approval was received. This introduces a delay into the process that hopefully would not exceed four to six weeks. With this time frame in mind, it was planned to commence work and installations in early 1981 and complete most the work by the fall of 1981. The energy consultant would have to maintain close supervision over the contractors doing the work. It was expected that many would not be entirely familiar with some of the types of installation and would require feedback from the consultant at various points during the work.

Some of the retrofit work such as replacement of windows with insulated walls, changing boiler controls, caulking of cracks or furnace overhaul would have to be carried out during the summer. Other projects would have to be put in during evenings and weekends to avoid class disruption. These include projects such as controls changes, installation of setback thermostats, attic insulation and so on.

This might involve the need for some supervisory work by the consultant outside of normal working hours. The consultant would also ensure that the custodian and principal are aware at all times about what changes are being made, how they work and how they affect the operation of the school. Communications problems and misconceptions about projects would be minimized by making staff aware of what is going on during installation and how it will benefit them.

3.7 Evaluation of All Components

The evaluation of the project as a whole involves a number of approaches from within the branch and outside the government.

There are several methods by which success of the three project components are gauged:

1. Monitoring of monthly energy consumption in each school after retrofit installations are complete to calculate the trend in energy performance.

2. Observing environmental conditions in the building to determine whether comfort has been improved or at least maintained.

3. Interviews of building users to determine their perceptions and attitudes regarding the conservation measures.

4. Survey of teachers using the curriculum resources and their impressions of these services.

The first two methods would be within the scope of each energy consultant to undertake. The last two methods would be better served by making use of an outside survey service.

An unbiased evaluation using all these means should provide sufficient evidence to either justify or criticize the effort and financing committed to the project.

The first evaluation measure. monitoring energy use after retrofits are complete, ideally requires a year of operation to get valid data.

The month-by-month energy efficiency figure is calculated in such a way that twelve months of energy consumption (after changes are complete) are required to see the full effect of the measures on reduced energy use. This would manifest itself in a steadily decreasing energy performance figure that eventually would reach a steady state level.

Within this twelve-month period, one would begin to see the trend in energy efficiency improvement. Seasonal variations in energy use do not show up in this trend because of the way that the monthly performance figure is calculated. This becomes the most concrete and objective data available to measure the effect of conservation measures on energy use.

The second mode of evaluation, observation of the comfort conditions after conservation measures, is an ongoing survey. Each energy consultant observes for himself, as well as questioning staff and custodians about environmental conditions in each area at various times and during different weather conditions. If a cold winter occurs during this observation period, the low temperature extremes provide a rigorous test of all the retrofit projects.

This is preferable to a case where a mild winter is encountered during the evaluation period because potential cold temperature problems may not surface. Instead, these problems would manifest themselves after the project is complete in the school with no consultant readily available to diagnose the cause and effect relationship.

Ideally, all possible problems would be discovered, rectified and monitored during the project duration, but this cannot be guaranteed. Most problems associated with low temperature extremes will have a great effect on interior comfort conditions.

The remaining two methods of evaluating the project are undertaken by an outside consultant hired for this purpose toward the end of the project.

This outside consultant surveys and interviews all affected user groups, from custodians, teachers, principals, school board personnel to students. Their opinion on repercussions due to the conservation initiatives are recorded to gain an overall understanding of the impact of this program on the project schools. A separate report is submitted by the outside consultant and becomes part of the overall evaluation of the project.

4.0 Project Findings

4.1 Energy Consumption/Performance Trends

The most objective and concrete method of determining whether an energy conservation program is saving energy is to monitor the utility bills or meter readings before and after improvements are made.

The effect of technical retrofits as well as the effect of improved operating practices will manifest themselves in reduced consumption figures (normalized for heating degree days). This does not necessarily translate into reduced energy costs because cost escalation usually outruns the reduction in energy use. In any case, there is a cost avoidance, since the building owner would be paying even more for utilities if the energy efficiency had not been improved.

Collection and translation of historical utility bills was an important first step in the audit process. It enabled one to see the existing energy use profiles and calculate existing energy efficiency.

In the course of the two years, consumption data was collected so that a total of 5 years is available for each school. Appendix #13 lists energy use profiles for each school. There are three graphs on each page.

The first graph shows the heating degree profile for that location from January 1981 to May 1982.

The second graph shows the heating degree profile for that consumption (normalized for building area) for the same duration, January 1981 to May 1982.

The third graph shows the calculated monthly energy performance trend from January 1981 to May 1982. If there is an improvement in efficiency, it would appear as a line of decreasing value.

The natural gas monthly profile should correspond fairly closely with the shape of the heating degree day curve. There is also a set of 3 graphs for each zone that indicate average energy performance trends.

A short recap of the zone energy consumption and efficiency profiles is described in the following:

Zone 1 - Monthly electrical consumption is fairly constant over the period. The natural gas figures correlate well with the degree day profile. Energy performance starts at about 1700 $MJ/m^2/a$ and levels off at about 1600 by the end of the period. Degree days are much greater in the winter of 1982 than that of 1981.

Zone 2 - Monthly electrical consumption is fairly constant over the period. Natural gas and heating degree day profiles correlate closely. Energy performance starts at about 1600 and levels off at about 1450 by the end of the period. Again, 1982 degree days are much greater than those in 1981.

Zone 3 - Monthly electrical consumption is fairly constant. The natural gas profile corresponds to heating degree days except for a few minor anomalies. Energy performance starts at about 1500 and ends up the period at about 1500. Heating degree days are much greater in 1982 than 1981.

Zone 4 - Monthly electrical consumption is fairly constant. The natural gas usage corresponds closely to the heating degree day profile. Energy performance starts at about 1500 and rises to about 1650 at the end of the period. Heating degree days increase greatly in 1982.

Zone 5 - Monthly electrical consumption is fairly constant. The natural gas and heating degree day profiles are similar. Energy performance begins at 1600 and decreases to about 1500 at the end of the period.

The trends in energy performance up to May 1982 show only a small decrease (if any) from the figure in January 1981, before any technical modifications were instituted. Because heating degree days were much greater in 1982 than 1981 it is expected that the performance trend would likely rise. If energy efficiency figures were normalized for degree days, a marked decline in the performance curve would result. It is a credit to the success of the technical modifications that performance coefficients did not rise very much.

Because many retrofits were not installed until March or April 1982, they have had little effect on the resulting utility bills. It will require monitoring and graphing of monthly consumption figures through the rest of 1982 to see the full effect of these measures. It is still anticipated that efficiency will improve by 20 percent once data for all of 1982 is in.

4.2 Energy Budgets

One of the three major objectives of the fifty schools project was to develop a set of energy performance standards for schools in the province. This would enable those embarking on a conservation program to have a firm idea on what kind of energy efficiency they could expect after making improvements. In the initial steps of the program, existing energy performance figures were calculated for all the schools, yielding an overall average of 1585 MJ/m^2/year.

Towards the end of the project, the energy consultants made an educated guess at what the average energy performance would be in their improved school. This figure was 1250 MJ/m^2/year, which represents an average 22 percent improvement over the overall original energy performance.

In addition, another analysis was done to statistically determine the effect of various factors on resulting energy use and efficiency. These factors were compiled for each school and include:

1. Wall construction type
2. Heating degree day for that zone
3. Area of school in square meters
4. Original school construction year
5. Grade level (elementary, junior or senior high)
6. Number of storeys (one, two or partial second floor)
7. Typical hours of operation (8, 12 or 18 hours/day)
8. Type of heating system (steam, hot water, hot air)
9. Maintenance level
10. Compactness

Various combinations of independent energy use factors were compared to several dependent variables in a computer program that performs an "Analysis of Variance". Seven groupings of four independent variables with one dependent variable were analyzed as shown in Appendix #9.

Energy performance (1981) was the dependent variable in three cases, gas consumption (1980) in two cases and gas consumption (1981) in two cases. The analysis of variance yields a figure called "significance of F" which represent the degree of correlation between a specific independent variable and the associated dependent variable.

A significance of F figure less than 0.1 represents a definite correlation while a figure greater than 0.1 means little or no correlation can be found with the data available.

Judging from Appendix #9, the following conclusions can be drawn:

1. Number of storeys, wall construction type, degree of compactness and level of maintenance appear to have a close correlation with resulting energy performance.

2. None of the other factors had a significant correlation with overall energy performance.

3. Building area, heating degree days and maintenance level appeared to have a close correlation with natural gas consumption in 1980.

4. Building area, number of storeys, degree of compactness, heating system type, maintenance level and heating degree days all had a close correlation with natural gas consumption for 1981.

5. Occupancy hours, original building age and grade level appeared to have no correlation with either natural gas consumption or overall energy performance.

The relationship between such factors as building area and heating degree days to resulting energy consumption was obvious, only confirmed by this analysis. Factors such as occupancy hours that were thought to have a great effect on energy use did not seem to bear a close relationship in this analysis.

This analysis does not indicate whether the relationship between the variables was direct, inverse or other. However, it does indicate the closeness of data points to a line representing a definite linear relationship between the two variables.

Because of this it can only be assumed that a compact configuration, a greater number of storeys, or a higher level of maintenance contribute to lower energy consumption (better energy performance). A larger sample size than fifty-two schools would enable more definitive results to be obtained on the relationship of energy using factors.

In addition to the Analysis of Variance, a simple calculation of building data averages and predominant system types was obtained:

1. Average energy performance to April 1982 was 1532 MJ/m^2/year

2. Average heating degree days were 5376 in 1980 and 5889 in 1982

3. Average school size was 3600 square meters

4. Average original age was 26 years old

5. Average number of storeys was just over one storey

6. Average hours of occupancy was 11 hours daily

7. Half of the 52 schools were elementary level

8. Hot water and forced air heating were the most common

9. Unitary and central fan ventilation was predominant

4.3 Energy Audits

Inspection of schools and energy audits and related analysis were conducted in the fall and winter of 1980. At that time the building envelope and thermodynamic data were collected and processed by hand in order to develop heat loss and energy balance figures. This proved to be a very tedious and time consuming task for all the consultants.

All the energy balance and retrofit payback figures were calculated in this manner and were used to priorize projects. In 1981 the consultant in Zone 4 started to consider the potential applications for a desk top microcomputer in the project. Following discussions within the branch, it was approved to let the school board in Zone 4 spend about $5,000.00 in project funds to purchase an Apple II microcomputer with two disk drives, a CRT monitor and a Centronics printer. Applicable programs were initially developed by the energy consultant for this unit.

One program developed is used to calculate payback periods using life cycle costing techniques. Factors such as energy cost escalation, interest rates and equipment depreciation are taken into account.

Another was designed to calculate the optimum thickness of proposed additional insulation in a wall or roof. Costs of extra insulation are weighed against cost of energy saved as a result to calculate the most economically justifiable amount.

A third program calculates and prints out general heat losses and gains in a school. Also output is the amount of energy required by the heating system to make up for heat loss and balance out losses and gains.

Another program accepts monthly energy consumption figures for electrical and gas, and calculates the energy efficiency trend. Graphs of all these consumption profiles are produced.

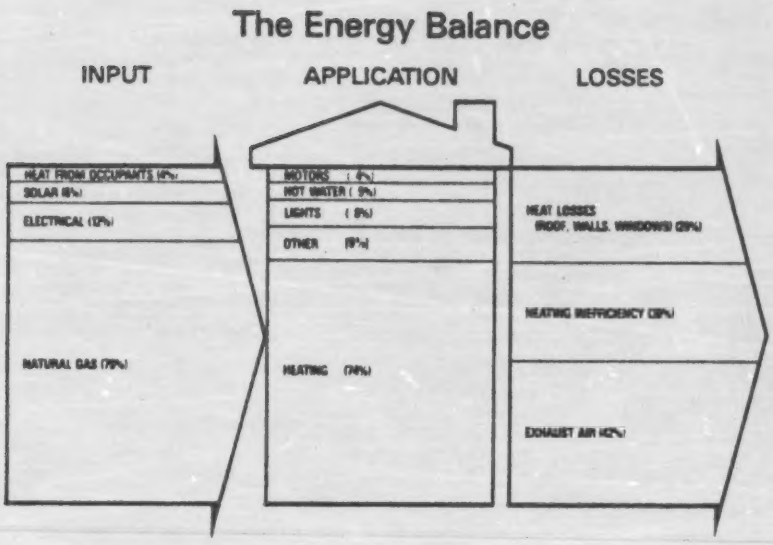
A package software program from the United States called F-Load was purchased in late 1981. This program was non-proprietary at the time and so it was possible for the energy consultant to modify it for project purposes. It is basically an energy use simulation analysis for a residential or light commercial building.

The program asks the user questions about building components, heating and ventilation equipment, operating hours and operating modes. It applies weather data for that locale to the building information and calculates individual heat losses and gains for 12 months as well as expected electrical and gas consumption.

Because of its original application, modifications had to be made for the program to simulate school construction and mode of operation. One of the main advantages of this type of computerized analysis is that changes can be made on-line to input data such as insulation levels, hours of operation or setback temperatures. The effect of these changes is shown in the revised monthly and total energy consumption figures. The effect of an operational change or retrofit can be simulated on the computer to get an indication of its effect on energy use.

This results in much more innovative, effective and rapid decision making.

SCHOOL ENERGY USE



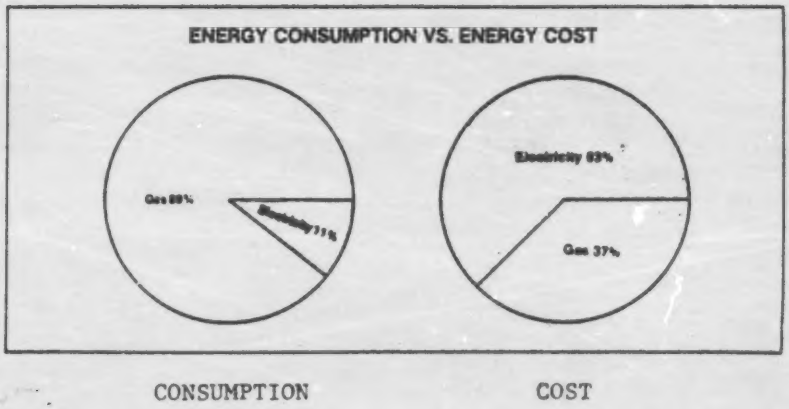


FIGURE #2

Zone 1

St. Thomas More

Wall construction was either brick or wood frame with 2" batt insulation or concrete block with loose fill insulation. Windows were double glazed. Roof was built up type with 2" of insulation. Heating was by hot air. Exhaust fans had capacity of about 2600 CFM.

Doors need weatherstripping and there were cracks in exterior walls. Vestibule doors were propped open. Furnace capacity was excessive. Water lines were insulated and urinals were flushed automatically. Classroom thermostats had night setback and there were no parking plug-ins. Lighting was too high or low in many cases. Occupants heat gain was 3% of total gain. Surface heat loss was 41% and infiltration loss was 28% of total losses. There was thermal stratification in the library. Fresh air intakes were oversized and dampers on classroom units malfunctioned.

Whitelaw

Wall construction was wood frame with 2" insulation. Windows were double glazed and roof was ventilated attic type with loose fill insulation. Heating was by hot air. Washrooms exhausted about 100 CFM.

Doors needed weatherstripping and vestibule doors were propped open. Fans run continuously through the heating season and thermostats had no setback. Water lines were not insulated and urinals flushed automatically. Occupants heat gain was 3% of total gain. Surface heat lost was 39% and infiltration loss was 34% of total losses. Hot air ducts ran through uninsulated crawl spaces. Furnaces were in great need of maintenance. Switch controls for washroom exhausts were not easily accessible. Furnaces had too much fresh air intake.

Fairview High

Wall construction was concrete block with loose fill insulation. Windows were double glazed and roof was built up type with 2" insulation. Heating was by hot air. Washroom exhaust capacity was 2200 CFM.

Doors needed weatherstripping, windows were often open, fresh air vents were in good condition. Exhaust vent in the gym passed much hot air. Outside incandescent lights were on continuously. Thermostats were often vandalized and urinals flushed automatically. Hallway lighting was excessive. Occupants heat gain was 11% of total gain. Surface heat loss was 41% and infiltration loss was 28% of total heat losses. Sliding windows often froze in the open position in winter. Classroom unit fresh air vents were often forced open or closed, causing cracked heat exchangers.

McAuley

Wall construction was wood frame with some wood shaving insulation. Roof was attic type with little insulation. Heating was done with forced air furnaces.

There were many cracks in walls, window and door frames. There were no vestibule doors. Distribution of hot air to classrooms was not well balanced. Urinals flushed automatically all year round. Furnaces did not have fresh air intakes but infiltration through the building envelope provided more than enough air.

E. E. Oliver

Wall construction was wood frame with 2" batt insulation. Windows were double glazed and roof was built up type with 1" to 4" rigid insulation. Heating was by hot water and hot air. Exhaust capacity was 750 CFM.

Doors needed weatherstripping and crawlspace vents were open. The hot water boilers seemed oversized. Thermostats had no night setback. Hot water lines were not insulated and ran through a crawlspace. Urinals flushed automatically. Occupant heat gain was 4% of total gain. Surface heat loss was 53% and infiltration loss was about 19% of total losses. Hot water circulation pumps did not shut down in warmer weather. The boiler temperature reset was malfunctioning, keeping water temperature higher than necessary. Fresh air dampers on fan unit did not close during unoccupied periods. Vestibule unit heaters had defective thermostats.

Hines Creek High

Walls were wood frame construction with 2" batt insulation. Windows were single pane with some storm units. Roof was vented attic type with 2" insulation or built up roof with 1" rigid insulation. Heating was by hot air. Exhaust capacity was 1000 CFM.

There were no vestibule doors and ducts were not insulated in crawlspaces. There was temperature stratification in the gym. Thermostats were not night setback type. Lighting levels were often too high or low and urinals flushed manually. Occupant heat gain was 2% of total gain. Surface heat loss was 34% and infiltration loss was 36% of total losses. The gym furnace pilot light tended to extinguish due to fan air blowing through cracked heat exchangers. Combustion air to furnaces had no damper control. Washroom exhaust switches were not easily accessible.

Grace Shepherd

Wall construction was wood frame with 2" batt insulation or concrete block with 1" rigid insulation. Windows were double glazed and roof was built up type with 2 or 3" batt insulation. Heating was by hot air. Exhaust capacity was 4165 CFM.

There were no vestibule doors and fluorescent lighting was not satisfactory. Car plug-ins were metered separately and paid for by the teachers. Some thermostats were not setback type. Ducts and hot water pipes were not insulated and urinals flushed manually. Occupant heat gain was 5% of total gain. Surface heat loss was 38% and infiltration loss was 35% of total losses. The roof mounted exhaust fan ran either continuously or not at all.

Brownvale

Wall construction was concrete block with 2" insulation. Windows were double hung type and roof was vented attic type with loose fill insulation or built up type with 1½" insulation. Heating was by hot air. Exhaust capacity was 250 CFM.

Doors needed weatherstripping and inner vestibule door was propped open. There was much settling of zonolite insulation in concrete block walls. There was temperature stratification in the gym. Water lines were not insulated. Urinals flushed automatically. Some windows were blocked off. A large hot water tank served showers that were rarely used. Occupants heat gain was 1% of total gain. Surface heat loss was 40% and infiltration loss was 28% of total losses. Fresh air intake was much greater than necessary and a vented crawl space was used as a return air plenum, causing heat loss. The gym furnace fresh air dampers remained open during unoccupied periods.

Lloyd Garrison

Wall construction was wood frame with 2" batt or concrete block with loose fill insulation. Windows were double glazed and roof was built up type with 1" insulation. Heating was by both hot water and hot air. Doors needed weatherstripping and vestibule doors were often propped open. Thermostats were not night setback type. Lighting was excessive in some areas. There was temperature stratification in the gym and urinals flushed automatically. Occupants heat gain was 2% of total gain. Surface heat loss was 32% and infiltration loss is 36% of total losses. Ventilation and exhaust fans ran continuously. Steam valves on classroom unit heaters were defective.

Grimshaw Junior/Senior

Wall construction was wood frame with 2" batt insulation. Windows were double glazed and roof was built up type with batt or rigid insulation. Heating was by steam and hot air. Exhaust capacity was 6800 CFM. Doors needed weatherstripping and vestibule doors were often propped open. Car plug-ins were energized continuously. Mechanical rooms were used for storage as well, blocking air intakes to furnaces. There was temperature stratification in the gym and urinals flushed automatically. Occupant heat gain was 2% of total gain. Surface heat loss was 33% and infiltration loss was 35% of total losses. Ventilation and exhaust fans ran continously. Boilers seemed to be oversized.

Kennedy Elementary

Wall construction was masonry block with no insulation. Built up roof had insulation of about R7. The heating was done by multizone furnaces. Exhaust fans had capacity of about 3300 CFM. Uninsulated hot air ducts ran through the ceiling space which was used as a return plenum. Exhaust fans ran continuously and room temperature settings were high to compensate for the radiant heat loss through the uninsulated walls. The fresh air damper on the multizone unit was forced open to 50 percent opening. Humidity levels in the winter were very low. An electric vestibule heater was installed in a new section, raising electrical demand substantially.

Zone 2

Ardmore

The wood frame construction used wood siding and stucco or brick. There were a few skylights and lots of double glazed casement windows except for the 1974 section, which had a few double glazed sealed units. There were no vestibules in the 1974 section.

Gas fired forced air heating was supplied by up-flow and counter-flow furnaces (some were converted oil burning furnaces), with an average efficiency of 70 percent. Ventilation was provided by furnace mixed air systems and exhaust fans. There were automatic and manual flushing urinals.

There was a low motor load resulting from furnace and exhaust fans. Incandescent lighting existed in corridors and washrooms, fluorescent lighting in instructional areas. Average peak demand was 40 KW and car plugs were metered separately. There was limited after hours use. Furnace fans ran continuously, and there was no night setback and poor mixed air control. Domestic hot water pipes required insulation.

Cold Lake

The old part was two storey wood frame construction with wood siding and stucco, and very large double glazed hopper windows. In the new section, masonry concrete block construction with large double glazed sealed units and a few skylights existed. Hot water heating in the old section was supplied by one fire tube boiler.

Gas fired forced air heating in new section was supplied by classroom furnaces. The boiler efficiency was 78 percent and the typical furnace efficiency was 70 percent. Ventilation was provided by exhaust fans with central exhaust for instructional areas and furnace mixed air systems. Manual flushing urinals existed. A high motor load resulted from furnace, exhaust and unit heater fans. Incandescent lighting existed in corridors, washrooms and showers, and fluorescent lighting in instructional areas. Average peak demand was 54 KW.

There was moderate after hours use. There was no boiler reset control and only manual operation of hot water circulation pumps. There was a day/night switch for furnace fans but no night setback and poor mixed air control.

Duclos

Wood frame construction used wood siding and stucco except for the 1959 section which was masonry concrete block construction. There were lots of skylights and double glazed casement windows.

Gas fired forced air heating was supplied by counter-flow furnaces and some classroom furnaces. Ventilation was provided by furnace mixed air systems and exhaust fans. Automatic flushing urinals existed.

There was a low motor load resulting from furnace and exhaust fans. Incandescent lighting existed in corridors, washrooms and showers, fluorescent

lighting in instructional areas. Average peak demand was 50 KW.

There was moderate after hours use. Furnace fans ran continuously except for classroom units which had day/night switches. There was no night setback and poor mixed air control. Domestic hot water pipes required insulation.

Fort Kent

One section used wood frame construction with wood siding and stucco. There were very large double glazed hopper windows. The 1965 section had masonry concrete block construction with large double glazed sealed units on the north elevation and a few skylights in the corridor.

Hot water heating was supplied by a fire tube boiler (efficiency 74 percent) in the old section and a cast iron sectional boiler (efficiency 82 percent) in the new section. Ventilation was provided by central exhaust fans in the old section and two air handling units in the new section. Automatic and manual urinal flushers existed.

There was a high motor load resulting from air handling units, circulation pumps, exhaust and unit heater fans. Incandescent lighting existed in corridors, gymnasium, washrooms and showers, fluorescent lighting in instructional areas. Average peak demand was 51 KW and car plugs were metered separately.

There was limited after hours use, no boiler reset controls and only manual operation of hot water circulation pumps. Air handling unit and exhaust fans ran continuously. Domestic hot water pipes required insulation.

Glendon

An older section used two storey wood frame construction with wood siding and stucco, and very large double glazed hopper windows on east and west elevations. The 1967 section used two storey masonry concrete block construction with insulated panels, a few skylights in the corridors and double glazed sealed units.

Hot water heating was provided by a fire tube boiler (efficiency 81 percent) in the old section and a cast iron sectional boiler (efficiency 76 percent) in the new section. Ventilation was provided by central exhaust fans in the old section and four air handling units with hot water coils in the new section. Automatic and manual flushing urinals existed.

A high motor load resulted from air handling units, circulation pumps, exhaust and unit heater fans. Incandescent lighting existed in corridors, gymnasium, washrooms and showers, fluorescent lighting in instructional areas. Average peak demand was 94 KW.

There was moderate after hours use, no boiler reset control and only manual operation of hot water circulation pumps. Air handling units ran continuously and domestic hot water pipes required insulation.

Grand Centre Elementary

An older section used wood frame contruction with wood siding and stucco and

large double glazed windows on north and south elevations. The 1978 section used masonry concrete block construction with wood siding and brick, double glazed sealed units and no vestibules.

Gas fired forced air heating in the old section was provided by converted (oil to natural gas) furnaces with an average efficiency of 62 percent. Hot water heating with terminal reheat in the new section was supplied by copper tube boilers (efficiency 78 percent). Ventilation in the old section was provided by furnace mixed air systems and gravity exhaust. A central air handling unit in the new section provided heated and humidified air. Automatic and manual flushing urinals existed.

There was a moderate motor load resulting from air handling units, circulation pumps, furnace, exhaust and unit heater fans. Incandescent lighting existed in corridors, stage and washrooms, fluorescent lighting in instructional areas and high pressure sodium in the gymnasium. Average peak demand was 62 KW and car plugs were metered separately.

There was moderate after hours use, furnace fans ran continuously, and there was poor mixed air control and no night setback. Domestic hot water pipes required insulation.

Grand Centre Junior

Masonry concrete block construction used brick veneer, and there was excessive window area on all elevations consisting of double glazed sealed units.

Gas fired forced air heating was supplied by classroom furnaces, and ventilation was provided by furnace mixed air systems and exhaust fans. Gravity exhaust vents were in the corridors and manual flushing urinals existed.

There was a low motor load resulting from furnace and exhaust fans. Incandescent lighting existed in the administration office, corridors, stage, washrooms and showers, fluorescent lighting in instructional areas. Average peak demand was 41 KW and car plugs were metered separately.

There was moderate after hours use, furnace fans ran continuously, and there was poor mixed air control and no night setback. Domestic hot water pipes required insulation.

Grand Centre Senior

Wall construction was two storey masonry concrete block construction with brick veneer with limited window area consisting of non-opening sealed units.

Gas fired heating was supplied by two stage multizone furnaces with electric humidifiers and single zone furnaces. Ventilation was provided by multizones and exhaust fans. Automatic flushing urinals existed.

There was a high motor load resulting from multizone supply and return fans, exhaust fans and vocational equipment. Fluorescent lighting was used with low voltage switching and luminous ceilings. Average peak demand was 300 KW.

There was extensive after hours use, fans ran continuously and there was no night setback. Z[illegible] dampers were controlled manually and humidifiers were not operational. Don[illegible]c hot water pipes required insulation.

Iron River

Wood frame construction used wood siding and stucco, except for the 1959 section which was masonry concrete block construction. There were lots of skylights and large double glazed casement windows.

Gas fired forced air heating was supplied by counter-flow furnaces, and ventilation was provided by furnace mixed air systems and exhaust fans. Manual flushing urinals existed.

There was a low motor load resulting from furnace and exhaust fans. Incandescent lighting existed in corridors and washrooms, fluorescent lighting in instructional areas. Average peak demand was 35 KW and car plugs were metered separately.

There was minimal after hours use. Furnace fans ran continuously, there was poor mixed air control and no night set back. Domestic hot water pipes required insulation.

Notre Dame Elementary

One section was wood frame construction with wood siding and stucco, large double glazed windows and clerestory windows. The 1965 section used masonry concrete block construction with brick veneer and large double glazed sealed units. The 1974 section had masonry concrete block construction with no windows.

Gas fired forced air heating was supplied by single zone and classroom furnaces. Ventilation was provided by exhaust fans. There were no mixed air systems on furnaces except for manual dampers on classroom furnaces. Manual and automatic flushing urinals existed. There was low motor load resulting from furnace and exhaust fans. Fluorescent lighting was used and average peak demand was 54 KW. There was moderate after hours use, a day/night switch for classroom furnace fans, but no mixed air or night setback. No regular maintenance was practiced.

Notre Dame Junior

The partly two storey masonry concrete block construction used brick and insulated panels, windows were double glazed sealed units, and no vestibules in central foyer existed. Gas fired heating was supplied by one multizone furnace, some single zone furnaces and several classroom furnaces. Ventilation was provided by a large supply fan on the multizone, manual dampers on the classroom furnaces and central exhaust fans. Automatic flushing urinals and flow duration control on showers existed.

There was a low motor load from furnace and exhaust fans. Fluorescent lighting was used and the average peak demand was 54 KW. There was extensive after hours use, day/night switching for classroom furnace fans but no night setback. No regular maintenance was practiced.

Zone 3

Austin O'Brien

The walls were of masonry construction and the roof was a built up type. Heating was provided by hot water.

Boiler efficiency was measured at 83%. Fluorescent lighting was predominant and consumed about 100 KW of demand. The motor load was 75 KW and parking plugs were 30 KW. Average daily occupancy was about 12 hours. Filters needed replacing, light diffusers needed cleaning and the boiler required adjustment. Many areas had dark wall and floor surfaces, and over illumination existed in other areas. Shower and urinal water use was excessive. Insulation levels were low and infiltration was high. There was no control on parking plugs, and no night shutdown or setback controls in the school. Natural gas used 82% and electrical formed 18% of total energy used.

Father Lacombe

Walls were of masonry construction and the roof was a built up type. Heating was done by hot water. The boiler operated at 79% efficiency.

The motor load was 12 KW, lighting power load was 38 KW and car plugs were 10 KW. Average school occupancy was about 12 hours per day. Of the total energy use, electrical formed 8% and natural gas formed 92%.

St. Agnes

Wall construction was masonry and the roof was a built up type. Heating was done by steam. The boiler efficiency was about 76%.

Motor load was 10 KW, lighting power load was 30 KW and car plug load was 10 KW. The school occupancy was about 16 hours per day. Of total energy use, electrical was 8% and natural gas was 92%.

St. Alphonsus

Wall construction was masonry, and the roof was a built up type. Heating was done by hot water. Boiler efficiency was about 80%. The motor load was 40 KW, lighting power load was 95 KW and car plug load was 8 KW. Average occupancy was 16 hours per day. Electrical used 10 % and natural gas was 90% of the total energy.

St. Andrew

Wall construction was wood frame with stucco siding. Heating was provided by steam and hot air. The boiler efficiency was about 85%.

Motor load was 11 KW, lighting power load was 40 KW and car plug load was 13 KW. Of total energy use, electrical formed 5% and natural gas formed 95%.

St. Augustine

Wall construction was masonry and the roof was a built up type. Heating was

done by hot air and the furnace efficiency was 72%.

The motor load was 9 KW, lighting power load was 32% and car plug load was 9 KW. Average occupancy was about 12 hours per day.

There were problems with damper operation in the multizone units and it was not possible to admit 100% fresh air when appropriate. Of the total energy use, electrical formed 15% and natural gas formed 85%.

St. Basil

Wall construction was masonry and heating was done by hot water. The boiler efficiency was 81%.

Motor load was 40 KW, lighting power was 48 KW, and car plug load was 20 KW. Occupancy was about 12 hours per day. There were problems with infiltration through leaky dampers. Of the total energy use electrical power was 4% and natural gas was 96%.

St. Boniface

Wall construction was masonry and heating was done by hot water and hot air. Boiler efficiency was 79%.

The motor load was 20 KW, lighting power load was 18 KW and car plug load was 13 KW. The average occupancy was about 12 hours per day. Thermostats were in great need of calibration. Of the total energy use, electrical power was 17% and natural gas was 83%.

St. Clare

Wall construction was masonry and the roof was a built up type. Heating was provided by steam and hot air. The boiler efficiencies were about 73%.

The motor load was 20 KW, lighting power load was 36 KW and car plug load was 11 KW. Average occupancy was about 23 hours per day. Of the total energy use, electrical was 10% and natural gas was 90%.

St. Dominic

Wall construction was masonry and heating was provided by hot water and hot air. The boiler efficiency was about 76%.

The motor load was 23 KW, lighting power load was 43 KW and car plug load was 19 KW. Average occupancy was about 12 hours per day. Of the total energy use, electrical power was 14% and natural gas was 86%.

Zone 4

Andrew Sibbald

Wall construction was masonry single storey with average R7 insulation. There were large window areas and skylights. The roof was a built up type with insulation level of R11. Heating was by hot water. There was no fan ventilation, only exhaust.

There were no vestibule doors. Boiler efficiency was about 80%. There was no night setback on thermostats or fan shutdown control. Lighting was primarily fluorescent and motor load was small. Exhaust fans caused 80% of the heat loss. Electrical peak demand reached about 74 KW. Occupants provided 4% of the heat gain. Surface heat loss was 30% and loss through windows was 5% of the total.

Beiseker

Wall construction was wood frame or masonry with R9 insulation level. Industrial arts used steel frame walls. The roof was a built up type with R11 insulation. Window areas had been reduced in some cases. Heating was by a steam boiler or forced air.

Lighting was mostly fluorescent with incandescent fixtures in the gym. Motor load was small. There was no night setback on thermostats or fan shutdown. Heating zone control was very good. Occupants provided 4% and solar heat provided 8% of the heat gain. Surface heat loss was 30% and infiltration was 4% of the total. Electrical peak demand was about 75 KW.

Chestermere

Wall construction was masonry with R9 insulation level. Much of the window area had been reduced and there were several skylights. The roof was a built up type with R8 insulation level. Heating was done by hot water and forced air with efficiency of about 75%.

There was no fan shutdown and motor load was moderate due to the number of exhaust and furnace fans. Thermostats had no night setback. School was used extensively in the evenings. Occupants provided 5% of heat gain. Heat loss through exhaust was about 40% and surface loss was about 30% of the total. Fluorescent lighting predominated and peak demand was about 125 KW.

Cochrane High

Wall construction was masonry with insulation value of R13. Zonolite had settled greatly in these walls. The roof was a built up type with R11 insulation. Heating was done by hot water. Some areas had fan ventilation and others relied on exhaust.

Boiler efficiencies were about 82% and rooms tended to overheat because there was no outdoor air control of pump shutdown. Occupants provided 3% and solar energy gave 6% of heat gain. Surface heat loss was 24% and exhaust losses were 50% of total. Fluorescent light was used but mercury fixtures were in the gym. Motor load was moderate. There was no night

setback or fan shutdown control. Electrical peak demand was about 97 KW. The school was used extensively on evenings and weekends.

Conrich

Wall construction was wood frame or masonry with R17 insulation value. The roof was built up type with R8 insulation. Window area was very great, causing large heat losses. Heating was by forced air and there were few exhaust fans.

Furnace efficiencies averaged 79%. Fluorescent lighting was used primarily. There was no night setback on thermostats or fan shutdown control. There was poor control of zone temperatures and mixed air. Surface heat loss was 37%, infiltration was 20% and exhaust air heat loss was 20% of the total. Occupants provided 4% of the heat gain. Electrical demand was about 47 KW.

Edwards

Wall construction was masonry with R17 insulating value. The roof was a built up type with R7 insulation. Window areas were quite small relative to other schools. Heating was done by forced air and exhaust capacity was fairly large.

Lighting was mostly fluorescent and seemed excessive in some areas. The motor load was moderate. There was no night setback on the thermostats or fan shutdown. Zone control of heat was poor. Surface heat loss was 32% and exhaust heat loss was about 20% of the total. Furnace efficiencies averaged 80%. Infiltration was a problem due to poor joining at the wall and roof. Occupants provided about 3% of the heat gain. Electrical demand was about 47 KW.

Elbow Valley

Wall construction was masonry with low insulation values of R4. There was little window area and skylights were used in the library. Heating was done by hot water in a terminal reheat system. There was large exhaust capacity. Infiltration was a great problem because of poor wall/roof joints. Fluorescent lighting was primarily used with excessive illumination in some areas. The motor load was relatively large. Boiler efficiency was about 78%. There was no night setback on thermostats or fan shutdown control. Surface heat loss was 30%, infiltration loss was 20% and exhaust loss was 20% of the total. Occupants provided 2% of the heat gain. Electrical demand peak was 115 KW.

Elizabeth Barrett

Wall construction was masonry with R17 insulation. The roof was a built up type with R16 insulation. There was very little glass area. Heating was done by hot water using terminal reheat coils and radiation. There was very large ventilation fan capacity.

Boiler efficiencies were about 83%. There was primarily fluorescent lighting in the building including the gym. The motor load was sizeable and the illumination level was relatively high. There was no night setback or fan shutdown control. Surface heat loss was 14%, and exhaust air loss was

35% of total. Occupants provided 3% of the heat gain. Electrical peak demand was about 95 KW.

George McDougall

Wall construction was masonry with R6 insulation. The roof was a built up type with R11 insulation. There were large window areas and several skylights were used. Heating was done by hot water and there was very little ventilation. Exhaust capacity was fairly large. Fluorescent lighting was mostly used, with mercury fixtures in the gym. The motor load was moderate. There was some night setback control but no fan shutdown. Boiler efficiency was about 76%. Surface heat loss was about 30%, and exhaust fan losses were 40% of the total. Electrical demand peak was about 100 KW. Occupants provided about 4% of the heat gain.

Springbank High

Wall construction was masonry with R7 insulation. The roof was a built up type with R9 insulation. There was only small glass area. Heating was done by hot water and heating or reheat coils. Exhaust fan capacity was quite large. Fluorescent lighting predominated, with mercury fixtures used in the gym. The motor load was high. There was ventilation fan shutdown but no exhaust shutdown or temperature setback. The school was used extensively on evenings and weekends. Boiler efficiencies were about 78%. Surface heat loss was about 27% and exhaust air loss was about 30% of the total. Occupants provided about 5% of the heat gain. Electrical demand peak was about 140 KW.

Springbank Junior High

One section was wood frame and the other was masonry construction with R9 insulation. Roof was attic type in one section and a built up type in the other with R9 insulation. Heating was done by forced air and steam boilers. There were no ventilation fans, only exhaust fans.

There was no night setback or boiler temperature reset. Structural damage was evident due to settling. Boilers and furnaces averaged about 77% efficiency. Uninsulated steam pipes and corroded steam valves tended to cause overheating. Fluorescent lighting was used throughout. The motor load was fairly small. All equipment ran continuously. Surface heat loss was about 35% and exhaust air loss about 36% of the total. Occupants provided 5% of the heat gain. Electrical peak demand was about 115 KW.

Zone 5

Alexandra

Wall construction was masonry, one storey and part two storey with R7 insulating values. The roof was a built up type with R9 insulation. Heating was done by hot water and mechanical cooling was used. Some window areas had been blocked off.

Fluorescent lighting was used except in the gym where mercury fixtures were installed. There was no fan shutdown or temperature setback. Gym lights were left on continuously. The boiler efficiency was 75%. Occupancy extended to evenings and some weekends. Exhaust air losses were 53% and surface heat loss was 25% of total. Average electrical demand was 134 KVA. Occupants provided 3% of the heat gain.

Connaught

Wall construction was masonry with R4 insulation and the roof was an attic type with no insulation. Some large window areas were blocked in. Heating was done by hot water and steam. One section had 100% fresh air ventilation.

Fluorescent lighting was used and there was a moderate motor load. There was no night setback or fan shutdown. Windows needed weatherstripping. Boiler efficiencies averaged 75%. There was some gym occupancy in the evenings. Exhaust losses were 38% and infiltration and surface heat losses were 43% of the total. Average electrical demand was 54 KVA. Occupants provide 2% of the heat gain.

Crescent Heights

Wall construction was masonry with R4 insulation. The roof was a built up type with R12 insulation. There were large window areas and several skylights. Heating was done by hot water and hot air. Mechanical cooling was used.

There was fluorescent lighting except in the gyms which had mercury fixtures. The motor load was fairly large. Boiler and roof top unit efficiency was 72%. The average electrical demand was 272 KVA. School occupancy extended to most evenings and weekends. There was no night setback or fan shutdown. Exhaust air losses were 46% and surfaces heat losses were 33% of the total. Occupants provided 3% of the heat gain.

Crestwood

Wall construction was masonry with R3 insulation. The roof was a built up type with R7 insulation and there were large window areas. Heating was done by hot water, and exhaust fans ran continuously.

There was fluorescent lighting except for the gym which had mercury fixtures. The motor load was moderate. The boiler efficiency was 78% and average electrical demand was 91 KVA. There was no night setback or fan shutdown. Exhaust air losses were 30% and surface heat losses were 50% of the total. The gym was used in the evenings. Occupants provided 3% of the total heat gain.

Elm Street

The wall construction was masonry with R4 insulation. The roof was an attic type with no insulation. Large window areas were partially blocked in. The ventilation system was 100% fresh air type.

Fluorescent lighting was used throughout and there was a moderate motor load. There was no night setback or fan shutdown control. Boiler efficiency was 75% and electrical demand was about 24 KVA. There was some evening use of the gym. Surface heat losses were 35% of the total. Occupants provided 1% of the heat gain.

Herald

The wall construction was masonry with R6 insulation. The roof was a built up type with R10 insulation. Heating was done by hot water and hot air. Mechanical cooling was used in parts of the school.

Fluorescent lighting was used throughout. The motor load was fairly high. There was no night setback or fan shutdown. Boiler efficiency was 75% and average electric demand was 56 KVA. Surface heat losses were 48% of the total. There was some evening use of the gym and occupants provided about 2% of the heat gain.

Montreal Street

The wall construction was masonry with R4 insulation. The roof was an attic type with no insulation. Heating was done by steam and hot water and there was no mechanical ventilation.

Fluorescent lighting was used except for mercury fixtures were installed in the gym. The motor load was light. There was no night setback control and the boiler efficiency was 75%. Electrical demand was only 27 KVA. Surface heat loss was 42% and infiltration air loss was 34% of the total. The school had no evening use and occupants provided 2% of the heat gain.

River Heights

Wall construction was masonry with R4 insulation. The roof was a built up type with R6 insulation. Heating was done using hot water. There were large window areas and some skylights.

Fluorescent lighting was used except for mercury fixtures in the gym. The motor load was moderate. There was no temperature setback but ventilation was normally controlled. The boiler efficiency was 75% and electrical demand was 42 KVA. Surface heat loss was 40% and exhaust air loss was 41% of the total. There was evening use of the gym and occupants provided 3% of the heat gain.

Vincent Massey

The construction was masonry with R6 insulation. The roof was a built up type with R4 insulation. There were large window areas and some skylights. Heating was done with hot water.

Fluorescent lighting was used except for mercury fixtures in the gym. The motor load was moderate and the boiler efficiency was 74%. There was no night setback or fan shutdown. Surface heat loss was 39% and exhaust loss was 43% of the total. The gym was used in the evening and occupants provided 4% of the heat gain.

Webster Niblock

The wall construction was masonry with R6 insulation. The roof was a built-up type with R4 insulation. There were large window areas and some skylights. Heating was done with hot water.

Fluorescent lighting was used except for mercury fixtures in the gym. The motor load was light and the boiler efficiency was 76%. There was no night setback or fan shutdown. Surface heat loss was 48% and exhaust air loss was 36% of the total. The gym was used in the evening and occupants provided 4% of the heat gain.

4.4 Corrective Measures Considered

The following table gives a list of possible retrofits for all energy waste problems uncovered as a result of the maxi-audit.

Problem	Corrective Action
Boiler/furnaces not operating at peak efficiency.	Flue gas analysis and burner adjustment.
No night setback of temperature.	Automatic night setback by installation of either day/night thermostats or load analyzer to reset hot water boiler tempurature.
Fans run continuously.	Tie all exhaust and ventilation fans into time clock.
Excessive air infiltration.	Tighten up building envelope by weatherstripping, caulking and patching of holes and cracks.
Excessive light levels.	Removal of fixtures and/or replacement with more efficient types.
Heating pumps running continuously.	Shut off hot water heating pumps above a set outdoor temperature.
Continuous steam supply regardless of outside temperature.	Shut off steam supply from boiler above a set outdoor temperature.
Poor/no mixed air control.	Provide for proper tie-in from thermostat(s) to damper motor to provide optimum mixed air temperature.
Insufficient light levels.	Install more efficient lighting source, such as high pressure sodium.
Insufficient wall/roof insulation.	Install optimum amount of extra insulation.
Excessive electrical demand.	Install microprocessor-based load monitor to shed electrical loads.
Constant boiler water temperature.	Provide indoor/outdoor controller to modulate hot water supply temperature.
Excessively large window areas.	Replace existing windows with insulated panels and better quality window units.
Start up/shut down of heating system not responsive to weather.	Install microprocessor-based optimal start/stop controller on heating plant.
Constant volume of air circulated by ventilation system.	Install proper controllers to convert constant volume setup to variable air volume.

Problem	Corrective Action
Fresh air being drawn into school at night.	Time clock controls the outside air dampers on heating system so that system will be on 100% recirculation after hours.
Only single set of doors at entranceways.	Install a vestibule entrance with double doors.
Large amount of heat being lost through exhaust fans.	Install heat recovery equipment to extract heat from exhausted air, transferring it to the incoming fresh air.
Scale buildup on boilers.	Institute boiler water treatment program.
School not on best electrical rate.	Consult with electric utility to ensure school is charged under optimum rate.
Lights on in schools even when ambient light from outside is sufficient.	Provide better switching so people can shut off just one row of lights or install automatic dimming system.
Uninsulated slab edge.	Insulate slab edge and/or berm up earth against edge.
No attic insulation.	Install R30 insulation and vapour barrier in attic.
Inefficient fluorescent lighting.	Install 34 watt fluorescent lamps.

4.5 Retrofit Selection Criteria

In the original maxi-audit, a return on investment formula was used, found on page 10 of Guidelines for Conserving Energy in Alberta Schools. Subsequent economic justification has been made either by simple payback calculations or life cycle costing (both on computer).

Generally, any retrofit with a return on investment (ROI) over 15% or a payback of less than 5 years was approved, as long as the capital cost was reasonable. For paybacks over five years, a retrofit was done only if needed for experimental purposes, or to be evaluated for other reasons apart from purely energy savings.

For example, window replacement has about a 40 to 50 year payback based on energy savings, longer than the proposed life of a building. However, apart from reducing heat loss, the retrofit reduces maintenance and vandalism. Also, if the local board is committed to replacing the existing windows anyway, an energy efficient replacement is superior.

In most schools, the following retrofits were done:

- flue gas analysis/burner adjustments
- vent/exhaust fan shutdown after hours
- night temperature setback

All three are applicable in most cases and each has a reasonably good payback. Originally, the burner adjustments were thought to have the best payback of about 1 to 2 months. However, as the efficiencies of the unadjusted furnaces and boilers was not as poor as originally estimated, the actual payback is under one year; payback on night setback is generally four years.

Where possible, fluorescent fixtures were removed to reduce both light levels and electrical consumption. Typically, this retrofit has a one to two year payback.

Computerized controls, although expensive, also exhibit excellent savings, with paybacks of four to five years possible.

Energy savings on projects such as proper mixed air control, and heating pump and steam supply shutdown on outdoor temperature are impossible to determine, although payback is probably in the three to seven year range.

Projects such as window replacement and the addition of vestibule doors cannot be justified from energy savings alone. Both retrofits were done in conjunction with an existing school board project.

Some projects, such as the conversion from mercury vapour to high pressure sodium lighting were done primarily for experimental reasons, although a payback of five years is expected. A proposed heat exchanger retrofit at one school was abandoned because of engineering and design problems.

4.6 Retrofits Installed

The actual retrofits installed in each school and associated costs are listed in Appendix #10.

4.7 Evaluation of Corrective Measures

4.71 Technical

Difficulties During Installation

Several zones experienced difficulties in finding suitable contractors to carry out the installations. Many of the retrofits involved work that mechanical, electrical and carpentry contractors were not all that familiar with. A number of modifications involved controls work on heating and ventilating equipment which electricians often preferred not to undertake. This generally had to be done by specialized controls contractors.

Because most of the retrofits were installed during the school year, it was necessary to schedule the work during nights, weekends and holidays to minimize the disruption of classes. Retrofits could not be done during the summer of 1981 because sufficient time was not allowed for B.Q.R.P. processing. When approvals were granted near the end of the summer the contractors had to order material and wait for it to arrive.

Materials required for the project installations were often in limited supply and delays of three months were common. This was compounded by the fact that other sectors were also starting to stock up on energy related supplies at the same time.

Extremely cold weather in the winter of 1981/82 effectively halted all progress on heating and ventilating retrofits temporarily. A common problem during installation was the uncovering of problems that often existed since the original construction. The rectification of the problems was not part of the original contract but still had to be done, increasing the retrofit installation time.

Most zones experienced problems with availability of controls servicemen to do installation. Zone 4 work was all done by one company which had difficulty in providing sufficient manpower. Zones 1 and 2 shared the same two-man controls contractor so installations took longer than planned.

In Zone 1 the energy consultant undertook several electrical retrofits, leading to problems because a non-licenced person cannot get electrical permits on inspections.

Contractual Problems

The only problem occurred in Zone 1 where it was necessary to abort an insulation contract at two schools when it was discovered that there was no vapour barrier in the ceiling. As a result, a redress payment was made to the contractor contingent on the contract being kept open for future completion at the original price.

Even though the specification/tender documents were very informal and simply written, there was no problems in holding contractors to the agreements.

Design Changes During Installation

In some schools water-saving retrofits, involving conversion of automatic flush urinals to door activated control, were reconsidered. Before installation the design was changed to timeclock operated flush control because some principals preferred to keep washroom doors open for surveillance.

In several cases installation of one component would point out deficiencies in design or maintenance of associated equipment.

For instance, night setback systems could not be fully operational until furnaces had fan shafts, bearings and filters replaced and burners, heat exchangers and return air grilles cleaned.

In one car plug cycling control project the method of cycling had to be reconsidered due to unforseen problems. Switching the whole parking load simultaneously put stress on the distribution system and thirty minute cycling intervals were too long in the harsh winter weather. The parking load was divided in two and cycled alternately and the time interval was reduced to fifteen minutes. As well, one plug could not be cycled to enable use by teachers for extracurricular activities after timeclock shutoff.

Thermostat guards for new night setback thermostats had to be changed to more vandalproof types due to tampering by students. Additional material was sometimes required after installation had begun, such as day/night setback thermostats, a load analyzer device, dampers and damper actuators and insulated window panels. In Zone 4 an electrical bus bar had to be extended to accommodate current transformers for a load shedder device.

In one school in Zone 1 the replacement of four furnaces brought to light a twenty-five-year-old construction defect. The new furnaces were not functioning properly into the ducts even though the ducts seemed to be of sufficient capacity. It was subsequently found that one main duct had been constricted to go over a hallway, greatly increasing static resistance for the fan. The duct was enlarged to remedy this problem.

Response and Feedback

It was very tempting for teachers and students to readjust settings on setback thermostats. Thermostat guards and set screws were added to hinder this action and many staff were displeased because they felt control over their environment was diminishing.

Window closures in a few cases caused an unfavourable reaction from staff due to the drastic change in environment. Several other aspects of the environment were improved to help make up for this change.

In a few cases, plants situated near cold surfaces during night setback in winter did not survive. Wall curtains and slightly higher night time temperatures helped to keep that from reoccurring. There were complaints by students of cold draughts in some classrooms, due to high ventilation rates from classroom units and fresh air louvres that did not close enough.

Some installations aroused the curiosity of students, and consultants were asked to make an explanatory presentation in the classroom. People are often opposed to change, regardless of whether that change is positive or negative. At the same time, the adaptability of people enables them to adjust to different conditions over a period of time. Positive feedback about the installations was often minimal because people do not speak up if there is nothing to complain about. If the retrofits were performing satisfactorily there was no need to report this success to anyone.

Car plug controls produced many complaints from teachers who felt that control of this electricity interfered with their personal property because they paid for this service. However, the school board was subsidizing the costs for this service so the true cost was shielded from the users.

Complaints about the new night setback controls were justified and this feedback was used to fine tune the schedule and magnitude of temperature setback. The most common situation was cold classrooms on Monday mornings in the winter. Any complaint about the school environment was usually forwarded to the energy consultant, whether it had anything to do with the installations or not.

There were also a few comments about odor buildup in washrooms and this problem was rectified by adjusting the operating times of the local exhaust fans.

Operational Problems

In a few schools the placement of night setback thermostats gave an inaccurate indication of room temperature. These were subsequently relocated. Also night setback of some classroom unit furnaces caused fan motors to freeze up in winter and trip breakers on start-up. In this case fan motors had to operate continuously and the opening for combustion air for the burners was reduced to the minimum.

In cases of night setback controls where a two stage furnace used only one stage for maintaining night time temperatures, one had to ensure this single stage could handle the night heating load during winter conditions.

Some twenty four volt setback control systems were not compatible with the furnace gas valves they were controlling and several devices had to be replaced to fix this problem.

It was found that night setback control systems using one stage of furnace heating were not sufficient to maintain night time settings, especially in leaky schools with poor insulation.

In Zone 2 one school had constricted under slab air ducts supplying air over hot water coils to heat the classrooms. During night setback the reduced airflow was not sufficient to provide the heating for the space. The problem existed before and was compounded by the lower night time settings. Also, one school with furnaces on night setback had problems with the pilot flame blowing out. This was traced to wind gusts from the combustion air vent and a deflector was put in to remedy the situation.

In several schools the time-clock-controlled shutdown of automatic urinal flushing caused water pipes to freeze up in winter. In these cases the time clock controls the shut down in spring, summer and fall but in winter the urinal flush will not shutdown at night so there is water flowing continuously in the pipes to prevent freezing.

Energy Saving Ability

In general it was believed from calculations and initial monitoring of the installations that the following retrofits were the most worthwhile:

1. Night shutdown of supply and exhaust fans was easily done, created few problems and had a quick payback.

2. Night setback of temperatures was relatively easy to implement but was not the answer in all cases and had a fairly short payback.

3. Reduction of fresh air intake was simple to do, and had a short payback.

4. Delamping of fluorescent fixtures was easily done, did not adversely affect required illumination levels and had a very short payback.

5. Conversion of incandescent to fluorescent fixtures or replacement of forty watt with thirty-four watt fluorescent tubes improved illumination and had a reasonable payback period.

6. High pressure sodium lighting conversions did not have a good payback but the lighting quality improvement was substantial.

7. Water saving devices were low cost, easy to install and had a good payback.

8. Insulation upgrading and window retrofits had poor paybacks and could rarely be justified on the basis of energy savings alone.

9. Microprocessor-based controllers could be justified in certain circumstances.

10. Burner efficiency improvement did not always pay off.

4.7.2 Staff Motivation

In several zones an attempt was made to set up instruction for the Building Operator 'A' course because a course like this could only succeed using a local instructor. Most custodial and maintenance staff were very receptive to the idea but some felt threatened about questioning of their use of energy.

In Zone 3 the extent of custodians's technical knowledge was evaluated early in the project. To upgrade their knowledge, monthly seminars were held, dealing with the basics of mechanical and electrical equipment operation. A Building Operator 'A' course was held for ten months so that head custodians could acquire certificates from the Boilers Branch. These people received salary increases if they successfully passed the exams. After this technical upgrading, it was found that custodians were operating their buildings more efficiently.

The energy consultant generally met with groups of school board administrators, teaching staff, custodians and the school board. Each group had different information requirements and different concerns.

In most schools motivation of staff was not given a high priority compared to the technical retrofit program. Staff apathy was very widespread and it presented a

great obstacle to success of motivational efforts. Usually the principal was the most positive toward the energy conservation activities conducted in the school. The consultants felt that the staff contribution toward operating efficiently was very small.

In Zone 4 the most effective staff motivation program was the teachers' involvement in their Energy Conservation Week in April, 1981.

The effectiveness of the local energy conservation committees varied from zone to zone. Some groups met regularly whether there were outstanding items to discuss or not. Other groups only met when there were specific items to discuss and decide on. Several zones had a high turnover rate in school board administration and principals which hurt the continuity of the energy conservation committees.

A certain amount of interest was generated in the school energy program simply by the presence of a conservation specialist in the system.

Energy conservation committees were charged with the responsibility of deciding on expenditures related to the program. Since the funding came almost entirely from the Energy Project budget or B.Q.R.P. support, the committee was less concerned about its use than if the source was school board funding. Often the committees just approved proposals by the energy consultant with little discussion.

A number of schools instituted meter reading programs to enable local monitoring of energy use. Custodians, teachers, or students were organized to perform weekly or monthly meter readings. This was quite a successful method for generating interest and involvement in the program.

The lack of real cooperation by teachers in the conservation efforts seemed to be due to several reasons:

1. Changing of ingrained habits such as remembering to turn off lights in unoccupied classrooms, since switching had previously been done by the custodian.

2. Many believed that their individual efforts were insignificant in the overall energy saving picture.

3. Teachers still harboured a number of misconceptions regarding energy use and school environment, such as the belief that it was better to leave fluorescent lamps on continously than switch them off periodically.

4. The lack of tangible incentives to reduce energy use was another factor. In most cases the school was not responsible for its own utility budget as would be the case in the individuals' homes.

In Zone 5 an incentive rebate system was instituted whereby a school that saved energy compared to a reference year would receive a portion of the saving from the school board to spend as it pleased. This was an extrinsic reward system which could be effective for several years provided a fair rating system was applied.

It was also felt by the energy consultants and others that energy management should be incorporated in some way into principals', teachers' and custodians' job descriptions.

Several motivational and information tools were set up as part of the project. The "Energy Conservation Quarterly Newsletter" was produced from the outset of the project and was sent to all school superintendents, secretary treasurers, principals and other agencies and individuals. The newsletter dealt with technical, motivational, and student involvement aspects of the energy program and was a successful method of informing those involved in school operation.

An audiovisual slide/tape presentation was produced in early 1982 to be used to introduce the program to various audiences in a crisp, concise format. It was well received by those who viewed the presentation since it was described in layman's terms.

In each zone "showcase" open house schools were organized in the spring of 1982 to present various aspects of the program to the public. The effort in organizing the open house was great and the quality of demonstrations was good but the attendance at most of the functions was disappointing.

All zones made good use of available media coverage, particularly newspapers. In some cases radio and television interviewed the consultants. This was ultimately the most effective way to publicize the program to the public. Cooperation from the media was always good and there were few cases of misinterpretation of information. In the smaller centres a reporter was often present at school board meetings so one had to be careful about wording or stating opinions on the conservation program in the schools.

4.7.3 Student Involvement

Efforts in student involvement in the project generally referred to the use of conservation related curriculum materials for various grade levels. The primary instigator in this aspect was Dan Stoker of the Energy Conservation Branch of Alberta Energy and Natural Resources. His primary function was to produce curriculum support materials for energy conservation and encourage their use in Alberta schools.

Early in the project in most zones, Dan Stoker, with the aid of the energy consultant, set up energy conservation student involvement committees that would map out strategies to implement this component. At this point there were few materials available for use from the Energy Conservation Branch.

Energy conservation curriculum materials already available were purchased by various schools:

1. Energy Conservation: A Curriculum for Living, produced by the Calgary Board of Education.

2. SEED's (School Energy Education Development) materials relating to the conservation ethic.

3. Locally developed units were used in several zones, covering topics such as solar, wind and nuclear energy in different subjects at various grade levels.

4. Film presentations such as Energy Management for the Future (NFB) and Leaving Something Over (Esso) were used as teaching aids.

5. One unit from the Houghton - Mifflin elementary science program.

6. The STEM energy conservation unit.

7. The Energy Conservation Branch "Glut Kit".

8. Federal government units on energy and transportation, school and home energy conservation.

Typical activities undertaken were simple energy audits of schools, draft detection, manual night setback programs, meter readings, monthly energy consumption graphing, efficient house design, energy conserving lifestyle surveys and various games and contests.

In Zone 1 the Fairview School Division creative writing magazine, Moose, had an energy theme. Prizes were awarded for the best student writing on this subject, such as "The Day the Sun Died" and "The Last Barrel of Oil".

In Zone 4 the single most effective student involvement activity was the "Energy Conservation Week" held at six elementary schools. An intensive set of energy conservation activities was organized and generated great enthusiasm in students.

Another part of the Energy Conservation Branch services was the Energy Van RSVP (Rural School Visitation Program) which visited most of the project schools and used puppet shows and other aids to impress energy conservation on children in elementary grades.

The consultants in several zones used student involvement bulletins to inform teachers about what curriculum materials were available, how conservation fit into their curriculum and activities that could be undertaken.

Student involvement committee members had been asked to submit proposals on spending of Energy Project funds on student involvement materials.

Curriculum materials were purchased for all grade levels using these funds. Funding was also used to pay teachers to produce local curriculum materials in a few cases.

It was concluded that student involvement was only successful if students learned through activities rather than by lectures. The student involvement component was successful at the elementary level, moderate at the junior high level and not successful at the senior high level.

While students were genuinely interested, there was a real problem with teacher apathy. They were unaware that energy conservation was already a part of the curriculum guides. They were hindered by a lack of suitable curriculum support materials, however.

5.0 Significant Findings

5.1 Findings of Interest

Problems

There were a number of concerns on the part of the consultants about factors that made their work more difficult:

1. It was difficult to calculate accurate energy consumption profiles and efficiency figures because of inconsistent utility billing, meter estimates, incorrect building area figures and conversion factors.

2. Construction drawings and specifications were not available for many school sections.

3. Dealing with several school boards at one time was often difficult.

4. It was difficult to retain the commitment of the energy committee over a two year period.

5. Manual data manipulation in the energy audit analysis phase was very tedious and time consuming.

6. The Building Quality Restoration Program required submissions at certain times to avoid a lengthy processing delay.

7. Initial inexperience of the energy consultants in this type of work slowed down the early phases of the project.

Successes

Initial monitoring of the retrofit installations in most zones indicates that energy efficiency is indeed improving. The use of a microcomputer to aid in energy analysis later on in the project proved to be one of the most effective methods of streamlining this type of work.

In general, staff were satisfied about the new energy efficient environment in their schools and there was a marked increase in awareness of energy use by staff and students.

The consultants had input into several new school designs that resulted in very energy efficient buildings being tendered. This is a very tangible result of the energy conservation program.

Preventative Maintenance

It became evident very quickly that a very rudimentary form of maintenance was performed on the mechanical and electrical systems in most schools. It was recognized that motivation of custodians and maintenance staff to undertake preventative maintenance was an essential step in wise energy use. This required close cooperation and good communications between the administration

and the maintenance staff. It was also found that preventative maintenance was less expensive than crisis repair situations, involving a shift of priorities and time scheduling.

It was mandatory in this aspect that the custodians technical knowledge of building systems must be upgraded. The importance of the building operator in energy efficient school operation had to be recognized.

Characteristics of an Energy Consultant

Once the energy consultants had gained some experience in the project, several characteristics were found to be helpful for one working in this field:

1. The consultant must have a sound knowledge of mechanical/electrical as well as structural systems.

2. One must be a good listener because there are many voices in schools waiting to be heard and their input is invaluable.

3. One must practice an energy conservation ethic in one's personal lifestyle.

4. One must be humble enough to admit that other people may have a better understanding of the interrelationship of factors in promoting energy conservation.

Student Involvement/Curriculum

It was concluded that an energy consultant is not adequately trained or oriented to manage a curriculum program. This area is best handled by education specialists. The engineer can aid the educator by providing technical background information but should not become involved in the administration.

The interest of those teachers involved is the key factor in the success or failure of a student involvement program. The degree of success is directly proportional to the effort expended by those involved. It was suggested that Alberta Education, especially the Curriculum Branch, must assume a more active role in the development and implementation of energy conservation curriculum materials.

Because the Alberta Education elementary science curriculum was relatively new, many teachers were unaware that energy conservation concepts were now core to the curriculum.

The higher the age group the more difficult it was to involve students in conservation activities--high school level teachers were apprehensive about trying new ideas on unresponsive students.

Retrofit Priorities and Spending

In most schools the majority of the funding was used in four types of retrofits:

1. Night setback thermostats
2. Time clock shutdown

3. Damper modification
4. General controls upgrading

Urinal flush control was a common modification in zones 1, 2, and 3. Attic insulation or window blocking were done in several schools in zones 1, 2, and 5. Windows were replaced in only one school in each of zones 4 and 5. Lighting modifications were common in zones 2, 4, and 5, while parking plug cycling was used in zones 2, 3, and 5. Microprocessor-based controllers were installed in zones 2, 3, 4, and 5 in a few schools.

Project fund spending per school ranged from a low of $480 to a high of $56,398. B.Q.R.P. funding support in each jurisdiction ranged from 50 percent to 250 percent of the project contribution. In only one case was there a contribution by the school board, in the amount of $5,800.

These comparisons would indicate that some schools undertook more retrofits supported by B.Q.R.P. and therefore received a greater contribution from this source than other schools. Although support is prorated on a 5 year basis this did not affect the potential support for any school because they were all more than 5 years old.

The average amount spent on a school was about $20,000 but the extremes ranged from $3,000 to $120,000 depending on the particular requirement. Most schools that used $20,000 or less had most of the economically justifiable retrofits installed. This indicates that in an average school most worthwhile conservation retrofits could be included within this budget figure. The financial requirement is inflated by retrofits involving the building envelope (ie. insulation, window replacement, vestibule doors). If these are not considered then $20,000 in 1980 dollars is reasonable.

5.2 Appraisal of Project Methodology

A study was conducted on the evaluation of the qualitative aspects of the fifty schools pilot project. This was undertaken from February to August 1982 by Stanley Associates Ltd., a consulting firm.

The objectives in this study were as follows:

1. To discover whether the objectives of the Phase 2 project were realistic and attainable.

2. To judge whether the processes chosen for completing the objectives were appropriate.

3. To decide whether the human and financial resources provided for the project were adequate.

4. To look at the current status of technical retrofits, motivational and student involvement programs in each zone to determine if there were weaknesses and areas for improvement.

5. To develop conclusions and recommendations that are designed to provide direction for a province-wide energy conservation program for schools.

The approach taken by the researchers was to a) review the technical retrofit cost breakdown to determine the types of modifications and associated spending priority, b) hold a workshop with the energy consultants to determine their perceptions of the work and the organization of the project, c) interview school board members in each participating jurisdiction as well as principals, teachers and custodians in the schools to record their perceptions of the energy conservation program.

Their visits with people involved in the project were to gain an understanding of the problems for those implementing the energy project as well as those receiving the services.

A number of interesting conclusions and comments surfaced once the information was collected from the interview questionaires of energy consultants and school jurisdiction personnel.

The first study mandate, to judge whether the three project objectives were realistic and attainable, yielded informative results. Relating to the first objective, most of the items in the "Guidelines for Conserving Energy in Alberta Schools" were used in implementing the project, but the energy consultants did not use it as a reference. Its usefulness to school boards is limited because many points are too general to actually act upon. Since cost justification was calculated for all retrofit projects, the economic practicality of many of the guideline items was confirmed. The fact that guidelines were published and distributed to schools was important, however.

The second project objective, to develop a set of feasible energy standards for schools has not completely been set. This is due to two factors. The energy performance of the project schools, before and after, was to have been

documented to see the average reduction in utility consumption. As of the completion date of this report, there has not been sufficient time to gauge the eventual effect of all the retrofits. At least another six months of utility data should be collected to determine the effect. A statistical analysis was done on the fifty-two project schools using data on energy consumption, operation hours, climatic locations, structural and mechanical configuration and so on. The analysis was designed to plot the energy using factors against the actual energy performance to try to find a correlation. Very little correlation was evident with most of the factors, possibly indicating too small a sample size.

In any case, it had been hoped that these correlations would help to develop a set of energy standards for different types of schools but this has not been possible so far.

The third objective, holding "open house" at schools to demonstrate the energy project was perceived by those attending to have been quite worthwhile. However, the turnout at most of the "showcase" schools was less than expected, possibly indicating that publicity was not as effective as it might have been. From the experience of those involved it appears that showcase schools are an effective method of demonstrating to the community the utility of an energy conservation program.

The second study mandate, to see whether the processes for project implementation were suitable, yielded a few insights. Overall, the program recipients believed that the handling of the project was quite adequate. The idea of Alberta Education providing engineers for a pilot project right in the school jurisdiction was lauded. The project objectives seemed to be well chosen and the means of gauging attainment of the objectives were well set out.

There were some specific comments about the B.Q.R.P. program, one being that changes could be made to this program to improve it, but that a certain amount of bureaucracy was inherent in this type of grant. Another administrator believed that the idea of school based utility budgeting would help motivate schools because savings in utility costs would be retained within the school.

The third study mandate was to look at the human and financial resources committed to the project. The respondents were very positive about the commitment of Alberta Education to this effort. However, there was some concern that not enough money had been spent on the motivational and curricular aspects. Some felt that only technical retrofits had been given priority and that the other two components should be more capital intensive. Another respondent felt that Alberta Education should pay for all conservation related retrofits since the schools had originally been constructed under departmental regulations.

The fourth mandate was to look at the current state of the technical, motivational and student involvement programs in each zone. Respondents generally perceived the technical retrofits to be worthwhile although some felt priorities were not always suitable and that modifications were causing discomfort, at least temporarily. Several thought that more should have been done to upgrade the building structure before controls upgrading, such as fan shutdown and night setback, was installed.

Most respondents were pleased with the efforts of Dan Stoker in promoting energy conservation in the curriculum.

They also felt that the energy consultant was not a suitable choice for active involvement in curriculum support and materials. Most agreed that it was important to teach energy conservation where it fits in the curriculum but that ready-made kits and materials must be available for their use.

The last mandate was to provide recommendations for the direction that a province-wide expansion of the program might take. One of the major conclusions that surfaced was that communications between energy consultants and school board administration, principals, teachers and custodians could stand much improvement.

Acceptance and credibility of the project had suffered because many were not aware of the intent of changes or what changes were actually being made. Many complained that they were not consulted before decisions were made on changes that affected their environment. One respondent felt that more priority should be given to ensuring that new school designs were energy efficient. There was a general concensus that a continuation of energy consulting services should come from the public sector. One suggestion was that energy consulting should be part of a facility planner's duties to enable a more integrated approach to good energy management.

6.0 Conclusions and Recommendations

A number of conclusions can be made about implementation of energy conservation in schools. Some of the salient points are:

1. Engineering expertise is definitely needed by most school jurisdictions to proceed with the task of saving energy.

2. There is still much inertia and resistance by individuals and school operations that obstructs complete success in wise energy use.

3. Many of the most effective technical and operational modifications can be implemented at minimal capital cost.

4. The B.Q.R.P. guidelines for conservation measures are a reasonably effective funding mechanism for the types of retrofits found to be practical.

5. Education and motivation of staff and students in wise energy use is an essential part of saving energy but automatic controls should also be used to lessen the dependence on the human factor.

6. Most of the suggested technical modifications listed in the "Guidelines for Conserving Energy in Alberta Schools" were found to be practical and were implemented in schools.

   Good housekeeping, to ensure mechanical and electrical equipment are operating as designed, is essential before conservation measures are applied to these systems.

8. Most of the operational measures in the "Guidelines" involved common sense suggestions and preventative maintenance, which have not been a high priority in many schools.

9. Education of custodians in good energy management is essential because they have a great effect on energy use. They are willing and able to learn as seen from efforts in custodial training.

10. Engineering input for energy efficient new school design has been solicited and appreciated by the Phase II jurisdictions and would likely continue to be a valuable service to provide.

11. The use of microprocessor-based control of building energy use is justified but the sophistication and cost of this control must be matched to the size, needs and magnitude of energy use in a school.

12. Computer aided energy use analysis has proven to be an essential part of building energy audits and retrofit design.

13. The consultant must have a good support from, and maintain good communications with, the decision makers in the school jurisdiction.

14. Maximum use of public relations tools and media exposure is essential for public awareness of energy conservation and support of departmental policies.

6.1 Policies

Based on the previous conclusions one can develop a set of policies that indicate to schools jurisdictions what the intent of the program is.

Alberta Education should:

1. Continue the use of B.Q.R.P. funding to support conservation measures. Without this source of funding it would be very difficult to convince boards to make improvements.

2. Use engineers as consulting resources to school jurisdictions to fill the gap in engineering expertise experienced by most boards.

3. Concentrate these consulting services in the rural and smaller urban areas where they are most needed.

4. Follow the guidelines for energy conservation and the B.Q.R.P. approved conservation measures, as they have proven to be practical and effective.

5. Let another group or agency handle the student involvement aspect since an engineer is not well equipped for these activities apart from initial promotion and cooperation with this group.

6. Publish a set of guidelines that are performance-oriented rather than prescriptive-oriented to enable jurisdictions involved in new school design to ensure energy efficiency.

7. Promote staff awareness and custodial training as a means to ensure wiser energy use in the schools.

8. Use public relations materials as an aid to publicizing to schools and the public at large the efforts and successes of energy conservation activities.

9. Coordinate the activities of energy conservation consulting in schools with similar or parallel activities of other departments or agencies to maximize its effectiveness.

6.2 Procedures

The experience gained from actually implementing a conservation program over a two-year period in a limited number of schools provides direction as to procedures that should be followed.

The first step in commencement of a conservation program is to make school administrators aware of what is involved. If their support is not apparent at this early stage it is useless to continue.

To develop a reference point at the beginning that indicates the state of existing energy performance it is essential that historical utility data be collected and analyzed. This is the only way that one can compare energy efficiency before and after improvements are instituted.

A school must be audited personally by an engineer. One cannot effectively guess at all the deficiencies in a specific school by lumping it in with conclusions and recommendations derived from schools of similar construction. The audit stage must involve study of construction drawings because most information can only be gained in this way.

Once data on operational characteristics, physical plant parameters and local climate are known, an analysis must be done to qualify the energy flows through the building and establish an energy balance. This analysis as well as appearance of obvious deficiencies in the building will indicate to an energy consultant what the problems are, how each may be corrected, and which are a priority. Priorities would be decided on the basis of potential amount of energy saved, cost of making the modification, resulting payback period and ease of maintenance.

The commitment of a school jurisdiction will become evident at this stage because it must form an ad hoc energy committee to decide on which modifications to proceed with. The jurisdiction should also make plans for an ongoing energy management, monitoring and awareness program.

Installation of technical retrofits for energy efficiency can take some time and as such it is not very effective for an energy consultant to be continously involved at this stage. Periodic inspection of installations should suffice, particularly once contractors become more familiar with these types of retrofits.

The ongoing monitoring program set up by the energy conservation committee would then be used to calculate the trend in energy performance once improvements are made to see whether, in fact, energy is being saved.

6.3 Energy Performance Standards

Based on the analysis of factors affecting energy use as outlined in Appendix #9, it appears that certain conclusions can be drawn. There are several clear correlations between specific factors and the resulting energy performance.

The average energy efficiency of the fifty-two schools at project commencement was about 1585 MJ/m^2/year. The average performance at the end of the project was 1532 MJ/m^2/year. This indicates already a reduction but it will take twelve more months of consumption data to gauge the overall effect of the program on these schools.

Sweetgrass school was designed to operate within a limit of 900 MJ/m^2/year and several new schools including Cochrane School are expected to operate under 750 MJ/m^2/year according to the mechanical designers involved.

Energy Performance

Once the energy use factors were catalogued for each school, the highest and lowest efficiency school (as measured at project beginning from each zone) was charted. The results are shown in Appendix #7.

A number of conclusions can be drawn from this comparison.

1. No single zone had a monopoly on the highest or lowest efficiency schools.
2. The most efficient schools originally were calculated at 800 to 1100 MJ/m^2/annum.
3. The most efficient schools averaged 2600 m^2 in area versus a 52 school average of 3600 m^2.
4. The most efficient schools were originally constructed around 1958.
5. The least efficient schools had efficiencies ranging from 2040 to 2574 MJ/m^2/annum.
6. The least efficient schools had an average size of about 3600 m^2.
7. The least efficient schools were typically built around 1970 and were elementary level.
9. The least efficient schools had a single storey and used a variety of heating and ventilating systems.

Also included in Appendix #7 is a chart called "Efficiency Statistics" that indicates the relationship between heating degree days and monthly gigajoule consumption in the project schools. There is a clear linear relationship between the two.

6.4 Future Initiatives

It is recommended that Alberta Education continue to support an in-house engineering group that would provide consulting services to all school boards in the province.

In order to reach as many jurisdictions as possible and still perform a sufficient depth of analysis it is preferable that perhaps only two schools per jurisdiction per year be subject to maxi-audits.

It is expected there would also be requests from school boards to study one component (e.g. skylights) or perform a short walk-through audit to find obvious deficiencies. The number of schools involved here would not be limited to a specific number.

It would be preferable for the energy consultants to handle the reporting and inspections on B.Q.R.P. applications for conservation items only. The consultant is more familiar with the types of retrofits involved and the required justification. This would apply whether the submissions resulted from a maxi-audit report or otherwise.

It is likely that energy consultants will become more and more involved with input into design of new schools and they will require guidance in this aspect. Also foreseen is the increased use of computer aided analysis to uncover energy use deficiencies and estimate the cost justification. Computer analysis will be essential in light of the number of schools requiring services.

As more schools are analysed and pertinent information extracted it will be possible to develop a sizeable data base on computer to determine energy use trends and define relationships between energy use factors and resulting efficiency.

Whether a funding mechanism such as B.Q.R.P. continues or not there will be justification for an energy conservation consulting service to continue in the future.

Appendix #1 **Grande Prairie Study Recommendations**

MEASURES FOR SAVING ENERGY

A. Human Management Practices (for administrators)

1. Work cooperatively with users in the implementation of measures.

   To gain acceptance, measures used to conserve energy must accommodate user preferences (within reason).

2. Monitor people's efforts and give them specific feedback on their performance.

3. Assign people specific responsibility for their work spaces.

   3.1 Teachers should see that classroom lights are switched off when rooms are vacant (recess, noon, after school).

   3.2 Shop instructors should selectively switch lighting when only portions of their shops are in use. Exhaust hoods should be operated as little as possible in winter, late autumn and early spring. During cold weather, use of exterior doors should also be minimized. Equipment should be operated in an efficient manner.

   3.3 The evening cleaning crew should set thermostats at night time levels at 1600 hours.

   3.4 The day crew should set thermostats at day time levels during the morning round of classroom checks (at 0700 hours).

   3.5 Thermostats enclosed in protective cases should be checked weekly, where possible.

   3.6 Staff should attempt to be economical in setting thermostats. Wearing a sweater is frequently preferable to turning up the heat.

4. Publicize the energy conservation program and results of energy consumption monitoring so that all groups within the schools are aware of efforts and achievements.

B. Seasonal Operation Practices

1. Summer

   1.1 Shut off all space heating systems.

   1.2 Shut off hot water heating systems where possible.

   1.3 Shut off ventilating systems for unoccupied areas.

   1.4 Shut off air-conditioning for unoccupied areas.

1.5 Minimize use of electric lighting systems.

1.6 Operate air-conditioning from 1000 hours to 1500 hours only in occupied spaces during work days.

1.7 Set internal temperatures at 22 degrees Celsius or higher when air-conditioning is operating.

2. Fall/Spring (September-October/April-June)

2.1 Set thermostats back to 13 degrees Celsius daily at 1600 hours.

2.2 Set thermostats to 20 degrees Celsius at 1900 hours each morning that classes are held.

2.3 In air-conditioning spaces operate the cooling system from 1000 to 1500 only during working days.

2.4 Maintain temperatures in cooled spaces at 22 degrees Celsius or higher.

2.5 Shut off ventilation systems daily at 1600 hours (this may be delayed for gymnasia and other areas used into the evening).

2.6 Turn on ventilating systems at 0800 hours each morning that classes are held.

2.7 Ensure that corridor thermostats are never set above 18 degrees Celsius.

3. Winter (November-March)

3.1 Ensure that no thermostats are set higher than 20 degrees Celsius when schools are not in use (check daily at 1600 hours).

3.2 Where pipe freezing, motor burnout and other hazards do not exist, set thermostats back to 16 degrees Celsius daily at 1600 hours.

3.3 Set thermostats to 20 degrees Celsius at 1900 hours each morning that classes are held.

3.4 Shut off air cooling systems.

3.5 Ensure that corridor thermostats are never set above 20 degrees Celsius.

4. Year-round

4.1 Substitute daylighting from windows and skylights for electric lighting where feasible.

4.2 Minimize use of electric lighting systems. Lights should be turned off in all unoccupied areas at all time.

4.3 During cleaning lights should be used only in the working area.

4.4 Ensure that all windows are firmly closed (check daily at 1600 hours).

4.5 Ensure that both outside and vestibule doors are firmly closed (check daily at frequent intervals, especially after periods of heavy traffic).

4.6 Ensure that leaking hot water taps are repaired.

C. Maintenance Practices

1. Electrical

1.1 Reduce illumination levels where acceptable, but maintain minimum standards:

- 540 lux in classrooms
- 110 lux in corridors
- 1100 lux in shop areas

Maintain an even distribution of light.

1.2 Ensure that burnt out lights are replaced immediately.

1.3 Ensure that luminaires are cleaned monthly.

1.4 Replace existing fluorescent tubes with low watt tubes (but maintain minimum lighting standards).

1.5 Reduce parking lot lighting to minimum levels required for safety.

1.6 Use proper size motors.

1.7 When redecorating, use light colours to achieve higher illimination levels.

2. Mechanical

2.1 Ensure that controls are calibrated and in good condition.

2.2 Clean air filters monthly.

2.3 Lubricate motors and other rotating equipment monthly.

2.4 Adjust outdoor air dampers for tight closure.

2.5 Adjust heating and cooling equipment to ensure maximum combustion efficiency.

2.6 External door mechanism should be removed so that doors will not stay open.

2.7 Clean strainer screens in water circulating systems at two month intervals.

2.8 Reduce air duct leakage.

3. Structural

3.1 Caulk window and door frames. Caulk cracks in walls.

3.2 Install weather stripping around windows and doors where not subject to excessive shifting.

3.3 Repair/seal broken windows.

D. Energy Management Program Organization

District Functions

- receive and assess weekly reports on energy consumption from each school
- produce and distribute district monthly energy use reports to the Board and to each school (including cost estimates)
- ensure that energy management measures are being implemented at each school
- provide technical assistance in implementing energy conservation measures
- obtain the mean daily temperature from the weather office, calculate the weekly average, and provide this figure to the schools
- check school energy consumption (monitor meters) at month end in June, July and August
- ensure that equipment is switched off in July and August

School Functions

- read natural gas and electricity meters every school day
- keep track of weekly energy performance
- evaluate whether performance is satisfactory based on records of energy use and the activity schedule for the building
- implement energy conservation measures
- ensure that all staff are aware of their responsibilities vis a vis energy management
- maintain graphs of weekly natural gas and electricity consumption indicators in the main entrance foyer of the school

Appendix #2 **Sweetgrass School Operation Study**

The Sweetgrass school project involved the design, analysis, construction and monitoring of an energy efficient school. A target energy performance figure of 250 KWH/m^2/year (900 MJ/m^2/year) was reasonable according to the building energy use computer simulations.

The school constructon was complete and occupancy commenced in 1979. Two years of operation of the building were monitored to study operational problems, building comfort levels and utility consumption figures. These findings were compiled into a report in November 1981.

Operational problems during this period included:

1. The volume varying mechanism on the ventilation fan did not react properly to ventilation demand or maintain correct pressure differentials, causing the school to experience a near negative pressure at times.

2. The variable volume boxes in the rooms did not sequence correctly with the perimeter radiation.

3. The variable volume boxes required calibration.

4. A lab exhaust fan was running continuously due to an override switch left on by mistake.

5. The boiler temperature reset control malfunctioned, requiring repair.

6. Air filters plugged up initially due to operation during construction.

7. Vestibule doors were found to be propped open and lights were often left on in unoccupied rooms.

8. Supply air temperatures reset control did not work properly due to incorrect placement of the sensor.

An infrared scan was performed on the building in 1980, indicating a very tight leak-free envelope.

School staff were satisfied with the environmental conditions. They appeared to function well under reduced light levels and fresh air quantities which were a part of the energy efficient design.

Weather data indicates that the 10 year average heating degree days is 5534. In 1980 the figure was 5195 and in 1981 it was 4593. This must be taken into account when calculating the energy efficiency figure each year.

It was estimated that construction of Sweetgrass cost about 8% more that a similar conventional school. Based on this figure and assumption of a 20% yearly escalation in utility costs the payback in energy saved would to about 10 years.

To correct the target performance of 250 KWH/m^2/year or 900 MJ/^{2}/year (based on 10 year average degree days), prorated targets of 234 (842) for 1980 and 207

(745) for 1981 were calculated to account for the lesser degree days in these 2 years.

From utility consumption data it was found that performance was 280 KWH/m^2/year (1008 MJ/m^2/year) in 1980, or 19% above the target. In 1981 the performance was 236/KWH/^{2}/year (850 MJ/m^2/year) or 14% above the target. These figures compare to an inefficient 611 KWH/m^2/year (2200 MJ/m^2/year) for the average school.

Factors that may have influenced the actual performance include wind velocity, sunshine hours, accuracy of meter readings, and extended hours of mechanical and lighting system operation.

It was concluded that extra costs for an energy efficient school are often negated by variations in tendered prices for construction, whether it be a conventional or energy efficient building.

The main conclusion was that an energy efficient school using readily available construction materials can be made comfortable and functional and still operate close to the performance guidelines of 250 KWH/m^2/year (900 MJ/m^2/year).

Appendix #3

Calgary Board of Education
Study Recommendations

These modification items in ranking order of dollar economy constitute the "ENERGY SAVING SHOPPING LIST" of modifications.

The column marked R.O.I. are items listed in order of greatest Return on Investment. The column marked $MJ/m^2/Yr$ constitutes the actual energy saved as a quantitive item when viewed without economic consideration. The column marked PAYBACK lists the years to recover doller first cost of modifications.

Formula for Return on Investment (ROI) data is obtained from:

$$R.O.I. = \frac{S - DC \times 100\%}{F.C.}$$

Where: S = Net annual utilities Savings in dollars.

DC = Depreciation Changes dollars per year = $\frac{FC}{EL}$

EL = Estimated Life remaining Briar Hill = 15 yrs. Roland Michener = 30 yrs.

FC = First Cost of modification (labour and materials).

Pay back period in years = PP = $\frac{FC}{S}$ = $\frac{\text{First cost of modification}}{\text{Annual savings of modification}}$

$MJ/m^2/yr.$ is obtained from MCF x 1055 = MJ gas energy/yr.
KW hrs. x 3.6 = MJ electrical energy/yr.

- BRIAR HILL MODEL -
ENERGY ECONOMICS SHOPPING LIST

(Based on Estimated Life of 15 Years)

Description	Pay Back Years	Energy Saving $MJ/M^2/YR$	R.O.I. %	Remarks
Domestic HW temperature reduction	0	5.4		No cost item
Univents on low fan	0.3	39.	300.	
Remove tubes from lights	0.5	4.2	200.	
Night set back thermostat and Chronotherm	0.7	120.	90.	
Time delay on washroom exhaust fans	2.4	25.	35.	
ExH fan off-on time clock	3.25	60.	25.	
Stage existing burners	3.8	126.	19.	
New multiple boilers	5.5	709.	12.	
Combustion air control and exchange fan via boiler room	5.6	95.	11.	
Univents cycle 2 instead of 3.	8.7	64.	8.5	
Remove ballasts from inactive lights	6.5	2.6	8.	
Weatherstrip doors.	7.8	8.6	6.	
Power burners	12.	90.	2.	
Heat recovery items on chimney	12.	190.	2.	
Vestibule thermostatic control	12.5	7.6	1.3	
Roof over sky lights	22.	21.	-ve	Not economical
Car plugs controlled	20.	--	--	Not recommended

- ROLAND MICHENER MODEL - ENERGY ECONOMICS SHOPPING LIST

(Based on Estimated Life of 30 Years)

Description	Pay Back Years	Energy Saving $MJ/M^2/YR$	R.O.I. %
Air conditioning rate	0	--	
Reduce domestic HW setting to 43 C	0	5.	
Time clock shut down of main fan only	0.64	18.	150.
Reduce lighting levels	0.6	0.4	150.
Set down boiler water temperature at night	1.	15.	60.
Improve fresh air and return air dampers to 90% shut off	2.1	20.	44.
Shut off water to idle boiler	2.5	76.	41.
Shut off return air fan during winter daytime	2.	2.6	40.
Control washrooms on door switch	2.	24.	38.
Automatically raised discharge air temperatures	2.5	20.	36.
Reduce hot water circulation pump rate to 60%	2.7	3.	32.
Set back all room temperature to 16 C at night	3.3	127.	26.
Switch off recirculation pump with thermostat	4.	2.5	22.
Central command monitor timing	4.	3.5	20.
Return fresh air dampers to minimum opening during heating season	4.6	56.	18.
Utilize return air fan to temper combustion air	5.5	39.	15.
Improved boiler water temperature control	5.7	5.7	14.
Install two-speed supply air fan motor	6.	25.	13.
Parking plugs times off with thermostat	6.	3.	12.
Install auto damper on combustion air	7.	9.	11.
Fresh air damper to minimum when outdoor temperature is 24 C	7.4	0.4	10.
Remove unlighted ballasts	8.	2.	7.
By-pass filter on circulation pump	11.4	5.6	5.

Appendix #4 **B.Q.R.P. Guidelines - Energy Conservation Factors**

The following are supported items related to the conservation project in the 1981 BQRP Guidelines:

1. **Structural Category**

a. Roof

Replacement of entire or major part of roof membrane and damaged insulation because of failure.

- removal of skylights
- additional roof insulation up to R12, or greater than R12 when accompanied by a roof load report

Age Factor - 20 years or more at 80% of approved support.
- under 20 years by proration or 20 years at 80% of approved support.

b. Windows and Glass Block

Replaced or blocked out due to failure of major components or excessive solar heating or heat loss.

Age Factor - 20 years or more at 80% of approved support.
- under 20 years by proration or 20 years at 80% of approved support.

g. Energy Conservation Factors

- insulation in attics
- additional insulation in exterior walls
- provision of vestibule enclosures to include two sets of doors
- replacement/new insulation on domestic hot water pipes
- heating equipment, duct and/or pipe insulation
- installation of watersaving devices
- installation of additional day/night setback control thermostats
- additional thermostats and control valves (for selective heat distribution)
- installation of automatic controls such as electric or mechanical time clocks
- installation of damper controls
- individual room light switching
- automatic controls for air circulation fans, temperature, exhaust and electric services (light switching)
- installation of outdoor temperature sensors
- replacement of existing lighting with energy efficient lighting
- installation of capacitors
- installation of time control clocks for car plugs

Age Factor - 5 years or more at 80% of approved support.
- under 5 years by proration or 5 years at 80% of approved support.

2. **Mechanical Category**

a. Heating Systems

i a). Forced air systems

- heating systems
- furnaces
- zoning
- ducting
- enlargement of system

Age Factor - 20 years or more at 80% of approved support.
- under 20 years by proration or 20 years at 80% of approved support.

ii. Steam, Hot Water

- heating system
- zoning
- enlargement of system

Age Factor - 25 years or more at 80% of approved support.
- under 25 years by proration or 25 years at 80% of approved support.

iii. Air Circulation Systems

Age Factor - 20 years or more at 80% of approved support.
- under 20 years by proration or 25 years at 80% of approved support.

3. **Electrical Category**

a. Replacement of incandescent fixtures

i. One for one in non-instructional areas

ii. Up to 1 four foot tube per 2 square metres (about 20 square feet) in classrooms and instructional areas.

iii. Up to 1 four foot tube per 4 square meters (about 40 square feet) in gyms.

b. Replacement of obsolete fluorescent fixtures.

Age Factor - 20 years or more at 80% of approved support.
- under 20 years by proration on 20 years at 80% of approved support.

Appendix #5 **PROJECT ZONE CLIMATIC CHARACTERISTICS**

	Location From Edmonton	Design Temp. (2.5%)	Heating D.D. C	Aver. Wind	Solar Insolation	Elevation
Zone #1	Peace River 520 KM Northwest	January -37 C July 27 C	6424	10km/hr.	12.0 $MJ/m^2/D$ 2000 hrs/yr	655 m
Zone #2	Cold Lake 240 KM Northeast	January -36 C July 28 C	6183	15km/hr.	12.6 $MJ/m^2/D$ 2100 hrs/yr	560 m
Zone #3	Edmonton	January -32 C July 28 C	5590	13km/hr.	13.0 $MJ/m^2/D$ 2150 hrs/yr	668 m
Zone #4	Calgary 300 KM South	January -31 C July 29 C	5344	18km/hr.	13.6 $MJ/m^2/D$ 2208 hrs/yr	1049 m
Zone #5	Medicine Hat 600 KM Southeast	January -31 C July 33 C	4872	16km/hr.	14.7 $MJ/m^2/D$ 2250 hrs/yr	721 m

Appendix #6

PROJECT SCHOOLS DESCRIPTION

Zone #1	Town or City	School Name	Elementary or High	Square Meters	No. Students 1980	Ports.	Date of Construction
Fairview S.Div. No. 50	Fairview	E.E. Oliver	Elementary	1036	203		1960
	Fairview	McAuley	Elementary	350			1955
	Fairview	Fairview	Senior High	3173	256		1965
	Hines Creek	Grace Shepherd	Elementary	1207	214	2	1955
	Hines Creek	Hines Creek	Junior/Senior	2768	172		1950
	Whitelaw	Whitelaw	Elementary	572	44		1956
Peace River S.Div. No. 10	Berwyn	Lloyd Garrison	Junior/Senior	2748	230		1956
	Brownvale	Brownvale	Elem/Junior	1583	46		1951
	Grimshaw	Grimshaw	Junior/Senior	2728	222		1959
	Grimshaw	Kennedy	Elementary	1813	222	4	1973
St. Thomas More R.C.S.S. Dist. No. 35	Fairview	St. Thomas More	Elem/Jr/Sr	4085	387		1956 (original demolished)
Zone #2	Ardmore	Ardmore	Elem/Junior	1924	206		1955
	Bonnyville	Duclos	Elem/Junior	2664	319		1954
Lakeland Public S.Dist. No. 5460	Cold Lake	Cold Lake Public	Elem/Junior	2616	232	3	1955
	Fort Kent	Fort Kent	Elem/Junior	3359	120		1954
	Glendon	Glendon	Elem/Jr/Sr	4576	426		1955
	Grand Centre	Grand Centre	Elem/Junior	2581/2924	322/178	2	1962
	Grand Centre	Grand Centre	Senior	6895	605		1972
	Iron River	Iron River	Elem/Junior	2288	159		1955
Lakeland R.C.S.S.Dist. No. 150	Bonnyville	Ecole Notre Dame	Junior High	2797	279	3	1961
	Bonnyville	Notre Dame	Elementary	4215	508	6	1953

Zone #3	Town or City	School Name	Elementary or High	Square Meters	No. Students 1980	Ports.	Date of Construction
Edmonton	Edmonton	Austin O'Brien	High	11070	432		1962
R.C.S.S.D.		Father Lacombe	Elementary	3047	107		1962
No. 7		St. Agnes	Elementary	2705	51		1950
		St. Alphonsus	Elem/Junior	7246	366		1949
		St. Andrew	Elementary	2751	123		1946
		St. Augustine	Elementary	2091	234	3	1972
		St. Basil	Elem/Junior	7833	537		1952
		St. Boniface	Elementary	2562	226		1967
		St. Clare	Elem/Junior	4785	201		1950
		St. Dominic	Elementary	3813	354	4	1968
Zone #4	Airdrie	George McDougall	High	38 9	412	2	1962
	Airdrie	Edwards	Elementary	3246	489	2	1972
Rockyview	Beiseker	Beiseker	Elem/Jr/Sr	3486	322		1951
S.Div. No. 41	Calgary	Chestermere	Junior/Senior	4525	481	1	1961
	Calgary	Conrich	Elementary	2372	301		1955
	Calgary	Elbow Valley	Elementary	3810	426	3	1971
	Calgary	Springbank	Junior High	5162	433		1946
	Calgary	Springbank Community	High	3744	317	2	1975
	Cochrane	Andrew Sibbald	Elementary	2849	382	7	1955
	Cochrane	Cochrane	High	3415	371	3	1962
	Cochrane	Elizabeth Barrett	Elementary	3497	386	6	1977

Zone #5	Town or City	School Name	Elementary or High	Square Meters	No. Students 1980	Ports.	Date of Construction
Medicine Hat S.Dist. No.76	Medicine Hat	Alexandra	Junior High	4818	488		1955
		Connaught	Elementary	3697	349		1912
		Crescent Heights	Junior/Senior	10068	906		1958
		Crestwood	Elementary	4288	412		1961
		Elm Street	Elementary	2594	144		1911
		Herald	Elementary	3189	258		1959
		Montreal Street	Elementary	1976	136		1904
		River Heights	Elementary	2160	247		1960
		Vincent Massey	Elementary	3155	406		1960
		Webster Niblock	Elementary	2200	291		1962

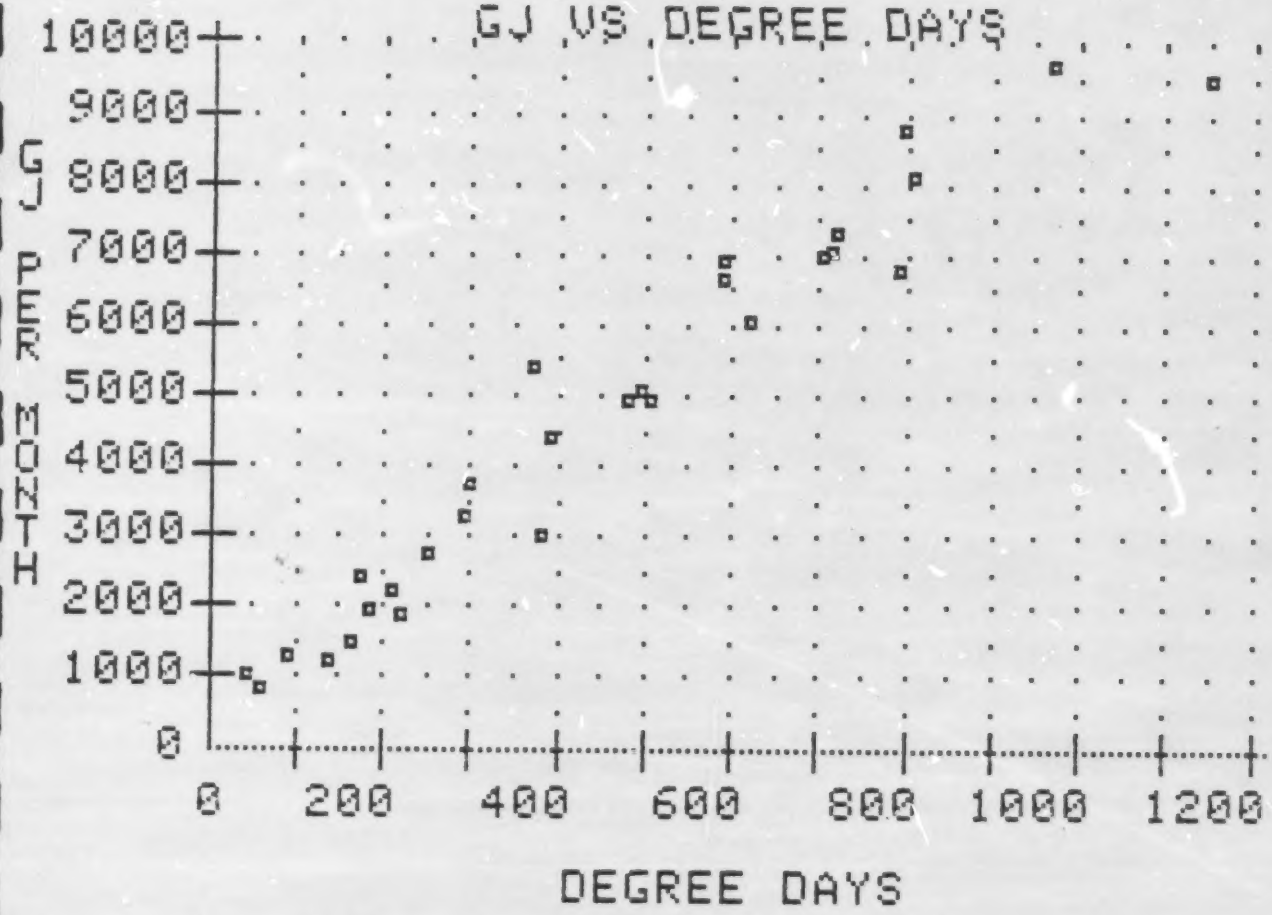
Appendix #7

Best and Worst School Comparison

Most Efficient Schools	Zone	1980 Eff.	1982 Eff.	Area m^2	Age	Grade	No. Storeys	Heat Type	Vent Type
Cold Lake	2	811	1326	2616	1955	EJ	1.5	HF	UN
Austin O'Brien	3	1018	964	11070	1962	E	2	HW	CF
Webster Niblock	5	1045	870	2271	1962	E	1	HW	CF
Hines Creek	1	1083	895	2768	1950	JS	2	FA	UN
Springbank	4	1102	1200	5162	1958	J	1.5	SF	EX
Least Efficient Schools									
Connaught	5	2574	2104	3817	1912	E	1.5	ST	CF
St. Augustine	3	2313	2048	2091	1972	E	1	FA	UN
Kennedy	1	2261	2130	1813	1973	E	1	FA	UN
Grand Centre	2	2138	1579	5646	1962	EJ	1	HF	CF
Elbow Valley	4	2040	2215	3810	1971	E	1	HW	CF
50 School Average		1585	1532	3600	1956	E	1.25	HF	UN/CF

HF = hot water/forced air heating
HW = hot water heating
FA = forced air furnace heating
SF = steam/forced air heating
ST = steam heating
UN = unitary (individual classroom) fan
CF = central fan
EX = exhaust fans only

EFFICIENCY STATISTICS



ZONE 1	BROWN-VALE	ST. T. MORE	E.E. OLIVER	Mc-AULEY	FAIR-VIEW H.	HINES CREEK	GRACE SHEP.	WHITE-LAW	LLOYD GARR.	GRIM-SHAW	KEN-NEDY
HEATING											
Steam Boiler									1	2	
Steam Boiler/ Heat Exchanger									1	1	
Hot Water Boiler		1	1						1		
Hot Air Gas Fired	6	18	14	2	23	15	13	3	7	11	15
Heat Pump											
Electric Heat											
Mechanical Cooling											1
VENTILATION											
Variable Air Volume											
Constant Vol./Mix Air/Heat Coil									1	1	
Cons. Vol./Fresh Air/Pre/Heat Coil											
Single Zone Furnace	4	13	14	2	9	10	3	2		6	3
Multizone Furnace											1
Class Unit Gas Fired		5			13	4	5	1	7	5	7
Class Unit/HW Heat											
Roof Top Unit Single Zone											
Roof Top Unit Multizone											
Unit Heat Gas Fired	2				1	1	5				4
Unit Heat Hot Water			3								
Heat Exchanger											
Exhaust Fan	2	6	8		9	3	2	1	6	4	3
Natural Infiltration				X							
HEAT DISTRIBUTION											
Hot Air Diffusers	X	X	X	X	X	X	X	X	X	X	X
Steam Radiators									X	X	
Hot Water Radiation		X	X						X		
Reheat Coils											
CONTROLS											
Pneumatic			X						X	X	
Electric	X	X	X	X	X	X	X	X	X	X	X

MECHANICAL SYSTEM CATEGORIES

ZONE 2	ARD-MORE	COLD LAKE	DUCLOS	FORT KENT	GLEN-DON	G.C. ELEM.	G.C. JR.	G.C. SR.	IRON RIVER	N.D. ELEM.	N.D. JR.
HEATING											
Steam Boiler											
Steam Boiler/ Heat Exchanger											
Hot Water Boiler		1		2	2	2					
Hot Air Gas Fired	11	6	19			13	21	13	11	29	17
Heat Pump											
Electric Heat											
Mechanical Cooling											
VENTILATION											
Variable Air Volume											
Constant Vol./Mix Air/Heat Coil				2	4						
Cons. Vol./Fresh Air/Pre/Heat Coil						1					
Single Zone Furnace	11		13			11	3	6	11	17	4
Multizone Furnace						2		7			1
Class Unit Gas Fired		6	6				18		—	12	12
Class Unit/HW Heat											
Roof Top Unit Single Zone											
Roof Top Unit Multizone											
Unit Heat Gas Fired					1						
Unit Heat Hot Water		11		17	13	4					
Heat Exchanger											
Exhaust Fan	4	10	7	17	19	6	12	16	3	7	11
Natural Infiltration	X		X			X			X		
HEAT DISTRIBUTION											
Hot Air Diffusers	X	X	X			X	X	X	X	X	X
Steam Radiators											
Hot Water Radiation		X		X	X	X					
Reheat Coils						X					
CONTROLS											
Pneumatic		X		X	X	X					
Electric	X	X	X			X	X	X	X	X	X

MECHANICAL SYSTEM CATEGORIES

ZONE 3	AUSTIN OBRIEN	FATHER LAC.	ST. BONI.	ST. ANDREW	ST. ALPH.	ST. DOMIN.	ST. BASIL	ST. AGNES	ST. AUGUS.	ST. CLARE	
HEATING Steam Boiler				2				2		2	
Steam Boiler/ Heat Exchanger											
Hot Water Boiler	2	2	1		3	4	2				
Hot Air Gas Fired	1		5	2	1	4			2	1	
Heat Pump											
Electric Heat											
Mechanical Cooling											
VENTILATION Variable Air Volume											
Constant Vol./Mix Air/Heat Coil											
Cons. Vol./Fresh Air/Pre/Heat Coil	4	1	2		2	2	2				
Single Zone Furnace									1		
Multizone Furnace									2	3	
Class Unit Gas Fired											
Class Unit/HW Heat											
Roof Top Unit Single Zone											
Roof Top Unit Multizone			1								
Unit Heat Gas Fired											
Unit Heat Hot Water											
Heat Exchanger											
Exhaust Fan				1	1		1	1		1	
Natural Infiltra- tion											
HEAT DISTRIBUTION Hot Air Diffusers			X	X	X	X			X	X	
Steam Radiators											
Hot Water Radiation	X	X		X	X	X					
Reheat Coils											
CONTROLS Pneumatic	X	X	X		X	X	X	X		X	
Electric				X					X		

MECHANICAL SYSTEM CATEGORIES

ZONE 4	ANDREW SIBBALD	BEI-SEKER	CHEST-ERMERE	COCH-RANE	CON-RICH	ED-WARDS	ELBOW VALLEY	ELIZ. BARRE	GEORGE McDOUG	SPRING COMM.	BANK JUNIOR
HEATING											
Steam Boiler		1									2
Steam Boiler/ Heat Exchanger											
Hot Water Boiler	2		1	2			2	2	1	2	
Hot Air Gas Fired		4	11		6	6					6
Heat Pump											
Electric Heat											
Mechanical Cooling											
VENTILATION											
Variable Air Volume											
Constant Vol./Mix Air/Heat Coil							1	1	1	1	
Cons. Vol./Fresh Air/Pre/Heat Coil											
Single Zone Furnace		4	11		6	6					6
Multizone Furnace											
Class Unit Gas Fired											
Class Unit/HW Heat											
Roof Top Unit Single Zone		1	1								
Roof Top Unit Multizone											
Unit Heat Gas Fired		1									
Unit Heat Hot Water											
Heat Exchanger											
Exhaust Fan	1	1	1	1	1	1	1	1	1	1	1
Natural Infiltra-tion											
HEAT DISTRIBUTION											
Hot Air Diffusers		X	X		X	X					X
Steam Radiators		X									X
Hot Water Radiation	X		X	X			X	X	X	X	
Reheat Coils							X	X		X	
CONTROLS											
Pneumatic	X	X	X	X			X	X	X	X	X
Electric	X	X	X		X	X					X

MECHANICAL SYSTEM CATEGORIES

ZONE 5	ALEXAN-DRA	CON-NAUGHT	CRES. HTS.	CREST-WOOD	ELM ST.	HERALD	MONT-REAL ST	RIVER HTS.	VINCE. MASSEY	WEBST. NIB.	
HEATING											
Steam Boiler		2					6				
Steam Boiler/ Heat Exchanger											
Hot Water Boiler	2		4	2	1	1	1	1	2	1	
Hot Air Gas Fired											
Heat Pump											
Electric Heat	1		1			1					
Mechanical Cooling											
VENTILATION											
Variable Air Volume											
Constant Vol./Mix Air/Heat Coil	1	1		3				2	3	2	
Cons. Vol./Fresh Air/Pre/Heat Coil											
Single Zone Furnace		1			1	1					
Multizone Furnace											
Class Unit Gas Fired											
Class Unit/HW Heat											
Roof Top Unit Single Zone						5					
Roof Top Unit Multizone			8			1					
Unit Heat Gas Fired											
Unit Heat Hot Water											
Heat Exchanger											
Exhaust Fan	4	1	22	5	3	6	2	8	10	5	
Natural Infiltration											
HEAT DISTRIBUTION											
Hot Air Diffusers			X								
Steam Radiators		X					X				
Hot Water Radiation	X	X	X	X	X		X	X	X	X	
Reheat Coils											
CONTROLS											
Pneumatic	X	X	X	X	X	X			X	X	
Electric			X			X	X	X	X		

Appendix #9

Analysis of Variance - Energy Using Factors

Note: A "Significance of F" figure of less than 0.1 indicates a clear correlation between the dependent and the independent variable.

Group	Dependent Variable	Independent Variable	Significance of F
1.	Performance	Storeys	.010
		Wall type	.018
		Shape	.056
		Maintenance	.053
2.	Performance	Occupancy hours	.628
		Area	.230
		Heating degree days	.861
		Age	.288
3.	Performance	Grade level	.707
		Area	.235
		Heating degree days	.863
		Age	.293
4.	Gas consumption 1981	Storeys	.004
		Wall type	.871
		Shape	.115
		Area	.000
5.	Gas consumption 1980	Storeys	.635
		Wall type	.816
		Shape	.684
		Area	.000
6.	Gas consumption 1981	Heating type	.095
		Maintenance	.002
		Heating degree days	.002
		Age	.223
7.	Gas consumption 1980	Heating type	.330
		Maintenance	.075
		Heating degree days	.043
		Age	.682

ZONE 1

PEACE RIVER SCHOOL DIVISION NO. 10

ST. THOMAS MORE RCSSD NO. 35

RETROFIT	KENNEDY		BROWNVALE		LLOYD GARRISON		GRIMSHAW				ST. THOMAS MORE		
	BORP	PROJ	BORP	PROJ	BORP	PROJ	BORP	PROJ	BORP	PROJ	BORP	PROJ	
NIGHT SETBACK THERMOSTATS	4111	1028	606	151	2927	732	5212	1303			3767	942	
TIME CLOCK SHUTDOWN	472	118	240	60	1382	345	776	194				1504	
DAMPER MODIFICATION	1352	338	684	171	199	50	471	118			802	200	
CONTROLS UPGRADING												4212	
BOILER TEMP. RESET												130	
HEATING PUMP CONTROL												810	
ZONE VALVE UPGRADE													
FURNACE REPLACEMENT											2700	2050	
COMPRESSOR UPGRADE							273	68					
WINDOW REPLACEMENT													
WINDOW BLOCKING												4719	
ATTIC INSULATION					8079	2020	9718	2429		1170 attic vents			
CRAWL SPACE INSULATION													
VESTIBULE DOORS													new
PIPE/DUCT INSULATION												1400	duct
WEATHERSTRIPPING												47	
HUMIDIFICATION		4500											
URINAL FLUSH CONTROL	495	124			1043	261	610	152			880	220	
SHOWER HEADS											168	42	
CEILING FANS											471	118	
LIGHT SWITCHING													
FLUORESCENT REPLACEMENT												187	
INCANDESCENT REPLACEMENT											2512	2059	
H. P. SODIUM LIGHTING													
PARKING PLUG CYCLE													
LOAD SHEDDER													
START TIME OPTIMIZER													
INFRARED SCANS	391	98	391	98	391	98	391	98				875	
BOILER TUNEUP													
MOTIVATION MATERIAL										2300			
CURRICULUM MATERIAL										3200		85	
OFFICE SUPPLIES										4268	(redress payme		
TOTALS	6821	6206	1921	480	14021	3506	17451	4362		10938	11300	19600	

PEACE RIVER SCHOOL DIVISION #10
TOTAL BORP = 40,214
TOTAL PROJECT = 25,492

ST. THOMAS MORE RCSSD NO. 35
TOTAL BORP = 11,300
TOTAL PROJECT = 19,600

FAIRVIEW SCHOOL DIVISION NO. 50

RETROFIT	HINES CREEK		GRACE SHEPHERD		WHITELAW		E.E.OLIVER		McAULEY		FAIRVIEW HIGH	
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS	1000	250	1458	365	479	120	1519	2369	742	158	869	92
TIME CLOCK SHUTDOWN	264	66	238	58	120	30					206	52
DAMPER MODIFICATION					629	157					309	77
CONTROLS UPGRADING					254	114		270		58		467
BOILER TEMP. RESET							1406	351				
HEATING PUMP CONTROL												
ZONE VALVE UPGRADE												
FURNACE REPLACEMENT	9677	7259									11976	11627
COMPRESSOR UPGRADE							287	336				
WINDOW REPLACEMENT												
WINDOW BLOCKING	80000	20000										
ATTIC INSULATION		5190	5423	1356	3618	854						
CRAWL SPACE INSULATION							310	78				
VESTIBULE DOORS			1000	250					680	170		
PIPE/DUCT INSULATION												
WEATHERSTRIPPING					69	17						37
URINAL FLUSH CONTROL							412	103	123	357	412	103
SHOWER HEADS											168	280
CEILING FANS												
LIGHT SWITCHING												
FLUORESCENT REPLACEMENT												
INCANDESCENT REPLACEMENT												
H.P.SODIUM LIGHTING												
PARKING PLUG CYCLE												
LOAD SHEDDER												
START TIME OPTIMIZER												
INFRARED SCANS												
BOILER TUNEUP												
MOTIVATION MATERIAL												
CURRICULUM MATERIAL										475		
OFFICE SUPPLIES										696		
TOTALS	90941	32765	8119	2029	5169	1292	3934	3507	1545	1914	13940	12735

FAIRVIEW SCHOOL DIVISION NO. 50
TOTAL BQRP = 123,648
TOTAL PROJECT = 54,242

LAKELAND PUBLIC SCHOOL DISTRICT NO. 5460

RETROFIT	ARDMORE		COLD LAKE		DUCLOS		FORT KENT		GLENDON		GRAND CENTRE ELEMENTARY	
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS			1440	360	5180	1295						
TIME CLOCK SHUTDOWN												
DAMPER MODIFICATION												
CONTROLS UPGRADING	3023	756	1408	352	4748	1187	4044	1627	9206	2570	2640	660
BOILER TEMP. RESET			704	176			1255	505	1263	497		
HEATING PUMP CONTROL			528	132			942	378	947	373		
ZONE VALVE UPGRADE							1177	473	1973	777		
FURNACE REPLACEMENT												
COMPRESSOR UPGRADE							824	331	828	327		
WINDOW REPLACEMENT												
WINDOW BLOCKING												
ATTIC INSULATION					5310	1327						
CRAWL SPACE INSULATION												
VESTIBULE DOORS												
PIPE/DUCT INSULATION	53	14			16	4	79	32	67	27	138	35
WEATHERSTRIPPING												
URINAL FLUSH CONTROL	282	70			563	141			505	199	169	183
SHOWER HEADS			116	29	145	36	155	62	143	56		
CEILING FANS												
LIGHT SWITCHING												
FLUORESCENT REPLACEMENT												
INCANDESCENT REPLACEMENT	449	112	2104	713	735	248	1183	408	2372	593	779	416
H.P.SODIUM LIGHTING												
PARKING PLUG CYCLE	1646	411	1663	416	1654	414	1483	596	2920	1150	1843	461
LOAD SHEDDER												
START TIME OPTIMIZER												
INFRARED SCANS		500		500		500		500		500		500
BOILER/FURNACE TUNEUP		472		214				259		259		1000
MOTIVATION MATERIAL												
CURRICULUM MATERIAL												
OFFICE SUPPLIES												
TOTALS	5453	2335	7963	2892	18351	5152	11142	5171	20224	7328	5569	3255

LAKELAND PUBLIC SCHOOL DISTRICT NO. 5460
TOTAL BQRP = 118,641
TOTAL PROJECT = 94,029

ZONE 2

LAKELAND PUBLIC SCHOOL DISTRICT NO. 5460

LAKELAND ROMAN CATHOLIC SEPARATE SCHOOL DISTRICT NO. 150

RETROFIT	GRAND CENTRE JUNIOR		SENIOR		IRON RIVER				NOTRE DAME ELEMENTARY		NOTRE DAME JUNIOR HIGH	
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS	5038	1260			3140	1610			4200	3980	4312	2078.
TIME CLOCK SHUTDOWN												
DAMPER MODIFICATION												
CONTROLS UPGRADING	3888	972	10854	19296	1983	1017			3392	3648	1280	2320
BOILER TEMP. RESET												
HEATING PUMP CONTROL												
ZONE VALVE UPGRADE												
FURNACE REPLACEMENT												
COMPRESSOR UPGRADE												
WINDOW REPLACEMENT											0	1451
WINDOW BLOCKING									4292	1073	7586	1897
ATTIC INSULATION					5310	1327						
CRAWL SPACE INSULATION												
VESTIBULE DOORS												
PIPE/DUCT INSULATION	202	50	78	20	123	64			5	1		
WEATHERSTRIPPING												
URINAL FLUSH CONTROL			845	211					563	141	282	70
SHOWER HEADS	116	29	174	43							116	29
CEILING FANS												
LIGHT SWITCHING												
FLUORESCENT REPLACEMENT												
INCANDESCENT REPLACEMENT	2993	945			2204	551						
H.P.SODIUM LIGHTING												
PARKING PLUG CYCLE			1751	438	1360	697						
LOAD SHEDDER			9880	35890								
START TIME OPTIMIZER												
INFRARED SCANS		500		500		500				500		500
BOILER TUNEUP												
MOTIVATION MATERIAL								1000				
CURRICULUM MATERIAL								976		750		250
OFFICE SUPPLIES												
TOTALS	12237	3756	23582	56398	14120	5766		1976	12452	10093	13576	8595

LAKELAND ROMAN CATHOLIC
SEPARATE SCHOOL DISTRICT NO. 150
TOTAL BQRP = 26,028
TOTAL PROJECT = 18,688

EDMONTON ROMAN CATHOLIC SEPARATE SCHOOL DISTRICT NO. 7

RETROFIT	AUSTIN O'BRIEN		ST. ANDREWS		ST. CLARE		ST. BONIFACE		ST. AUGUSTINE		ST. DOMINIC	
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS	19592	6978	400	100	400	100	800	200	800	4700	300	6200
TIME CLOCK SHUTDOWN												
DAMPER MODIFICATION												
CONTROLS UPGRADING				480		1200		920				
BOILER TEMP. RESET												
HEATING PUMP CONTROL												
ZONE VALVE UPGRADE				625		6875						
FURNACE REPLACEMENT												
COMPRESSOR UPGRADE												
WINDOW REPLACEMENT												
WINDOW BLOCKING												
ATTIC INSULATION												
CRAWL SPACE INSULATION												
VESTIBULE DOORS												
PIPE/DUCT INSULATION												
WEATHERSTRIPPING												
URINAL FLUSH CONTROL	1200	300	800	200	1200	300	1200	300			1200	300
SHOWER HEADS		200						180				130
CEILING FANS												
LIGHT SWITCHING												
FLUORESCENT REPLACEMENT												
INCANDESCENT REPLACEMENT												
H.P.SODIUM LIGHTING												
PARKING PLUG CYCLE	2800	700	2000	500	2000	500	2000	500	2000	500	2000	500
LOAD SHEDDER												
START TIME OPTIMIZER												
INFRARED SCANS		500		500		500		400		500		500
BOILER TUNEUP		1280		800		1600		1800		1280		1100
MOTIVATION MATERIAL		100		100		100		100		100		100
CURRICULUM MATERIAL												
OFFICE SUPPLIES												
TOTALS	23592	10058	3200	3305	3600	11175	4000	4400	2800	7080	3500	8830

EDMONTON ROMAN CATHOLIC
SEPARATE SCHOOL DISTRICT NO. 7
TOTAL BORP = 55,532
TOTAL PROJECT = 107,298

EDMONTON ROMAN CATHOLIC SEPARATE SCHOOL DISTRICT NO. 7

RETROFIT	ST. ALPHONSUS		ST. BASIL		FATHER LACOMBE		ST. AGNES					
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS	800	200	800	200		19000	400	100				
TIME CLOCK SHUTDOWN												
DAMPER MODIFICATION												
CONTROLS UPGRADING		1850		1890								
BOILER TEMP. RESET												
HEATING PUMP CONTROL												
ZONE VALVE UPGRADE				14375				1375				
FURNACE REPLACEMENT												
COMPRESSOR UPGRADE												
WINDOW REPLACEMENT												
WINDOW BLOCKING												
ATTIC INSULATION												
CRAWL SPACE INSULATION												
VESTIBULE DOORS												
PIPE/DUCT INSULATION												
WEATHERSTRIPPING												
URINAL FLUSH CONTROL	1000	200	1200	300	1200	300	1200	300				
SHOWER HEADS		150				270		180				
CEILING FANS												
LIGHT SWITCHING												
FLUORESCENT REPLACEMENT												
INCANDESCENT REPLACEMENT												
H.P.SODIUM LIGHTING												
PARKING PLUG CYCLE	2240	560	2000	500	2000	500	2000	500				
LOAD SHEDDER		7000		6250								
START TIME OPTIMIZER												
INFRARED SCANS		500		500		400		500				
BOILER TUNEUP		950		1050		1050		1100				
MOTIVATION MATERIAL		100		100		100		100				
CURRICULUM MATERIAL												
OFFICE SUPPLIES												
TOTALS	4040	11510	4000	25165	3200	21620	3600	4155				

ROCKY VIEW SCHOOL DIVISION NO. 41

RETROFIT	ANDREW SIBBALD		BEISEKER		CHESTERMERE		COCHRANE		CONRICH		SPRINGBANK JUNIOR HIGH	
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS	4000	2061	4800	1200	4800	1200	4000	2500	2400	600	4400	2200
TIME CLOCK SHUTDOWN	280	80					1200	300		100	400	65
DAMPER MODIFICATION								2300			1178	300
CONTROLS UPGRADING			1175	300			1200	300	2018	1358		
BOILER TEMP. RESET	800	1600					720	180				
HEATING PUMP CONTROL	800	200			1115	279	736	186				6299
ZONE VALVE UPGRADE												
FURNACE REPLACEMENT												
COMPRESSOR UPGRADE												
WINDOW REPLACEMENT									29705	29353		
WINDOW BLOCKING										+5800		
ATTIC INSULATION										(local)		
CRAWL SPACE INSULATION												
VESTIBULE DOORS		15000										
PIPE/DUCT INSULATION												
WEATHERSTRIPPING												
URINAL FLUSH CONTROL												
SHOWER HEADS												
CEILING FANS												
LIGHT SWITCHING												
FLUORESCENT REPLACEMENT												
INCANDESCENT REPLACEMENT												
H.P.SODIUM LIGHTING												
PARKING PLUG CYCLE												
LOAD SHEDDER												
START TIME OPTIMIZER			1000	244								
WATER TREATMENT										188		
INFRARED SCANS								500				500
BOILER TUNEUP		257		129		418		129		193		322
MOTIVATION MATERIAL												
CURRICULUM MATERIAL												
OFFICE SUPPLIES												
TOTALS	5880	19198	6975	1873	5915	1897	7856	6395	34123	31792	5978	9686

ROCKY VIEW SCHOOL DIVISION NO. 41
TOTAL BQRP = $ 105 502
TOTAL PROJECT = $ 112 290
TOTAL LOCAL = $ 5 800

ROCKY VIEW SCHOOL DIVISION NO. 41

RETROFIT	EDWARDS		VALLEY		BARRETT		McDOUGALL		COMM.HIGH			
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS			4400	1063	1200		3200	1167				
TIME CLOCK SHUTDOWN	1000	500	790	500	800	200	800	200	800	200		
DAMPER MODIFICATION												
CONTROLS UPGRADING												
BOILER TEMP. RESET					3170	1092			800	3000		
HEATING PUMP CONTROL			1000	300	800	200	133	100	1600	800		
ZONE VALVE UPGRADE												
FURNACE REPLACEMENT												
COMPRESSOR UPGRADE												
WINDOW REPLACEMENT												
WINDOW BLOCKING												
ATTIC INSULATION												
CRAWL SPACE INSULATION												
VESTIBULE DOORS												
PIPE/DUCT INSULATION												
WEATHERSTRIPPING												
URINAL FLUSH CONTROL												
SHOWER HEADS												
CEILING FANS												
LIGHT SWITCHING												
FLUORESCENT REPLACEMENT		720				1314				3241		
INCANDESCENT REPLACEMENT												
H.P.SODIUM LIGHTING										5468		
PARKING PLUG CYCLE												
LOAD SHEDDER									10240	7883		
START TIME OPTIMIZER	6042	1261	2000	500								
WATER TREATMENT				575								
INFRARED SCANS		500		500		500		500		500		
BOILER TUNEUP		257		161		64		32		129		
MOTIVATION MATERIAL												582
CURRICULUM MATERIAL												1127
OFFICE SUPPLIES												6313
TOTALS	7042	3238	8190	3599	5970	3370	4133	1999	13440	21221		8022

MEDICINE HAT PUBLIC SCHOOL DISTRICT NO. 76

RETROFIT	ALEXANDRA		CONNAUGHT		CRESCENT HEIGHTS		CRESTWOOD		ELM STREET		HERALD	
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS	7318	1830	6062	5000	22224	5556	8036	2009	5802	1696	8532	2133
TIME CLOCK SHUTDOWN												
DAMPER MODIFICATION		2300				21900		2600				
CONTROLS UPGRADING		900		700		3029		1400				1395
BOILER TEMP. RESET												
HEATING PUMP CONTROL												
ZONE VALVE UPGRADE				1470				1090				
FURNACE REPLACEMENT												
COMPRESSOR UPGRADE												
WINDOW REPLACEMENT									1823	456		
WINDOW BLOCKING												
ATTIC INSULATION			3929	982					3623	906		
CRAWL SPACE INSULATION												
VESTIBULE DOORS												
PIPE DUCT INSULATION					532	2043		2116				
WEATHERSTRIPPING		100		100		100		100		100		100
URINAL FLUSH CONTROL												
SHOWER HEADS		317				485		148				
CEILING FANS												
LIGHT SWITCHING										208		
FLUORESCENT REPLACEMENT		2010		713		3953		1604		650		1042
INCANDESCENT REPLACEMENT												
H.P.SODIUM LIGHTING												
PARKING PLUG CYCLE		2738		1596		1677		1649		1440		1440
LOAD SHEDDER												
START TIME OPTIMIZER												
INFRARED SCANS												
BOILER TUNEUP												
MOTIVATION MATERIAL												
CURRICULUM MATERIAL												
OFFICE SUPPLIES												
TOTALS	7318	10195	9991	10561	22756	38743	8036	12716	11248	5456	8532	6110

MEDICINE HAT PUBLIC SCHOOL DISTRICT NO. 76
TOTAL BQRP = 93,044
TOTAL PROJECT = 115,217

MEDICINE HAT PUBLIC SCHOOL DISTRICT NO. 76

RETROFIT	MONTREAL STREET		RIVER HEIGHTS		VINCENT MASSEY		WEBSTER NIBLOCK					
	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ	BQRP	PROJ
NIGHT SETBACK THERMOSTATS	3948	987	4513	2453	6622	2980	3208	1062				
TIME CLOCK SHUTDOWN												
DAMPER MODIFICATION												
CONTROLS UPGRADING												
BOILER TEMP. RESET												
HEATING PUMP CONTROL												
ZONE VALVE UPGRADE				2500		2500						
FURNACE REPLACEMENT												
COMPRESSOR UPGRADE												
WINDOW REPLACEMENT												
WINDOW BLOCKING												
ATTIC INSULATION	1437	359										
CRAWL SPACE INSULATION												
VESTIBULE DOORS	1515	379										
PIPE/DUCT INSULATION	3920	980										
WEATHERSTRIPPING		100		100		100		100				
URINAL FLUSH CONTROL												
SHOWER HEADS												
CEILING FANS												
LIGHT SWITCHING												
FLUORESCENT REPLACEMENT		205		591		1037		795				
INCANDESCENT REPLACEMENT												
H.P.SODIUM LIGHTING												
PARKING PLUG CYCLE		1440		1440		1682		1596				
LOAD SHEDDER												
START TIME OPTIMIZER												
INFRARED SCANS												
BOILER TUNEUP												
MOTIVATION MATERIAL												3450
CURRICULUM MATERIAL												3450
OFFICE SUPPLIES												1150
TOTALS	10820	4450	4513	7084	6622	8299	3208	3553				8050

Appendix #11

FINANCIAL SUPPORT

		Project Funding	B.Q.R.P. Support	Project Funds Spent	Total Spending	Board Contribution
Zone #1						
	Fairview S.D. No. 50	55,200	123,648	54,242	177,890	0
	Peace River S.D. No. 10	40,200	40,204	25,492	65,696	0
	St. Thomas More R.C.S.S.D. No. 35	19,600	11,330	19,600	30,930	0
TOTAL		115,000	175,182	99,334	274,516	
Zone #2	Lakeland PSD No. 5460	93,200	118,641	93,200	211,841	0
	Lakeland R.C.S.S.D. No. 150	21,800	26,028	19,517	45,545	0
TOTAL		115,000	144,669	112,717	257,386	0
Zone #3	Edmonton R.C.S.S.D. No. 7	*127,500	55,532	107,298	162,830	0
Zone #4	Rockyview S.D. No. 41	115,000	105,502	112,290	217,792	5,800
Zone #5	Medicine Hat	115,000	93,045	115,000	[illegible],045	0
Grand Total		587,500	573,930	546,639	1,120,569	5,800

* $12,500 of this amount was used to purchase measuring instruments for the consultants

Appendix #12 **Utility Rate Schedules**

City of Medicine Hat Power

General Service Demand Rate 3.3

1. April 1980 — February 1982

Demand Rate			
All KWH	1.7¢/KWH	All KWH	3.5¢/KWH
Demand Charge	$2.50/KVA	Demand Charge	$4.40/KVA

2. **Edmonton Power**

General Service

April 1981		April 1981	
		Demand Rate	
First 850 KWH	6.9¢/KWH	First 6200 KWH	5¢/KWH
Next 5350 KWH	4.6¢/KWH	Next 150 KWH/KVA	4.2¢/KWH
		Next 30000 KWH	3.2¢/KWH
		Over	2¢/KWH
		Demand	$6.22/KVA

3. **Alberta Power**

General Service Schedule 22

January 1980		April 1982	
First 40 KWH/KW	10.9¢/KWH	First 200 KWH/KW	9.4¢/KWH
Next 160 KWH/KW	6.5¢/KWH	Next 200 KWH/KW	6.7¢/KWH
Next 200 KWH/KW	4.4¢/KWH	Over	5.6¢/KWH
Over	3.6¢/KWH	Demand	$3.52/KW

4. **City of Medicine Hat Natural Gas**

General Service 3.1

August 1980		February 1982	
First 2 MCF	$3.70/month	First 100 MCF	$1.65/MCF
Next 98 MCF	42¢/MCF	Next 900 MCF	$1.46/MCF
Next 900 MCF	30¢/MCF	Over	$1.34/MCF
Over	22¢/MCF	Demand	$1.34/MCF
Demand	2.5¢/MCF		

5. **Northwestern Utilities**

August 1980	February 1982
11¢/therm	$2.33/GJ (24.6¢/therm)

6. **Bonnyville Gas Co.**

	Rate A
March 1980	February 1982
$0.90/MCF	$1.89/MCF

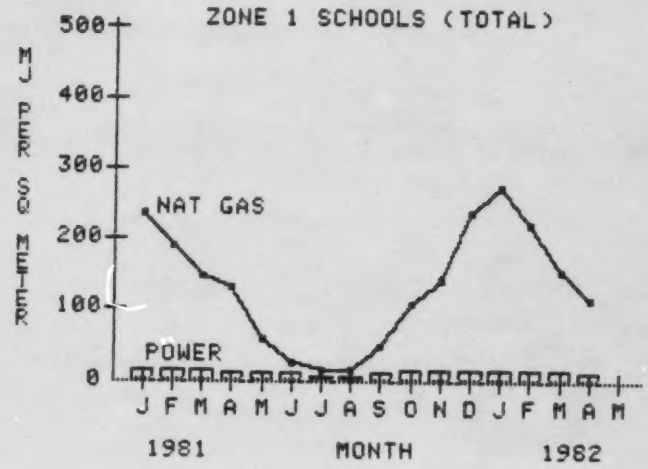
7. **Plains Western Gas Ltd.**

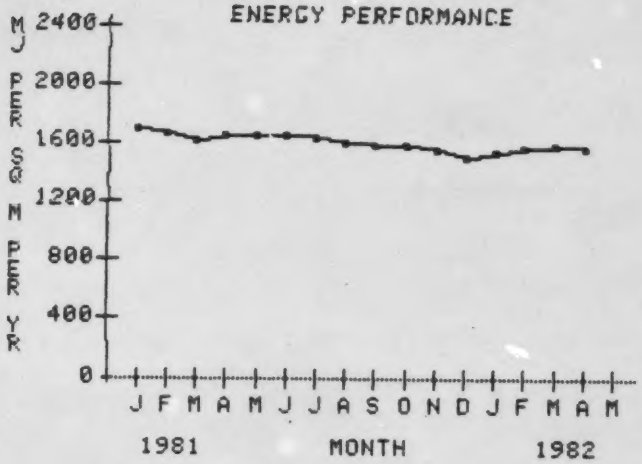
January 1980	February 1982
$1.29/MCF	$2.68/MCF

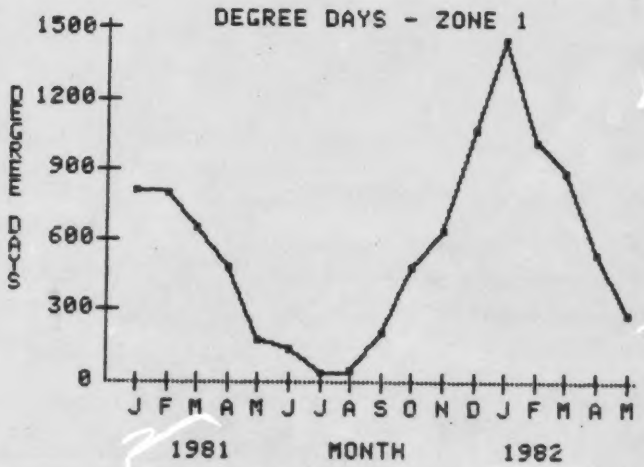
8. **Northeast Gas Co-op**

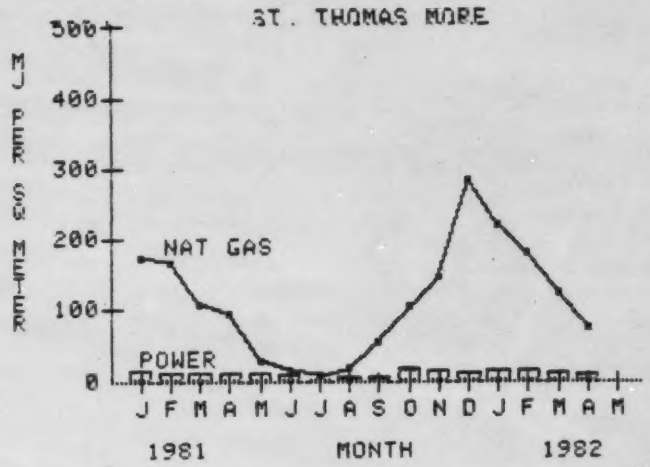
November 1980	March 1982
$1.85/Gigajoule	$3.68/Gigajoule

ENERGY USE/EFFICIENCY PROFILES





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300
200
100
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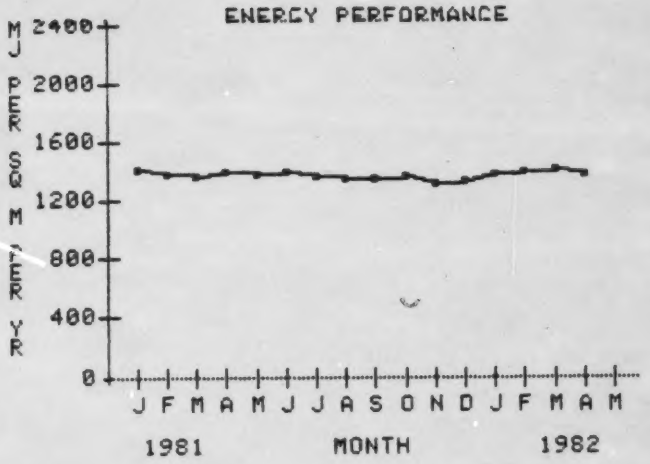
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982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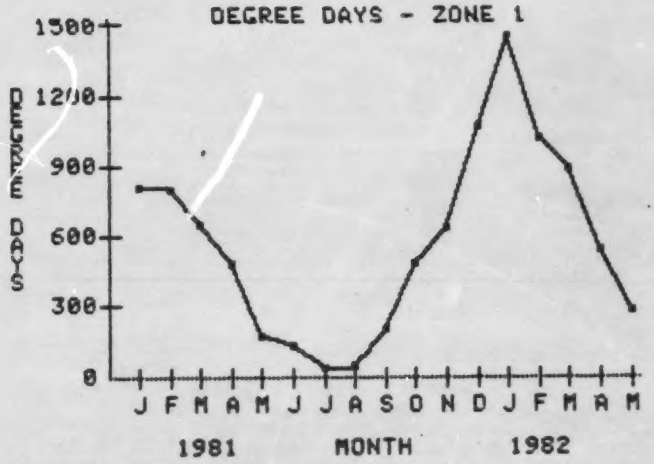
MONTH
1982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600
300
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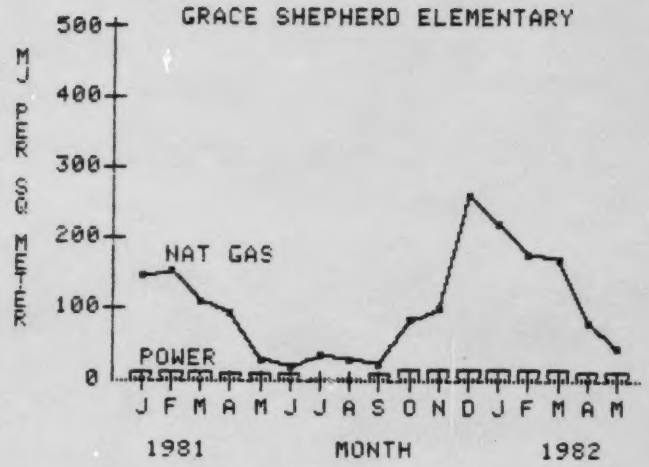
1981
MONTH
1982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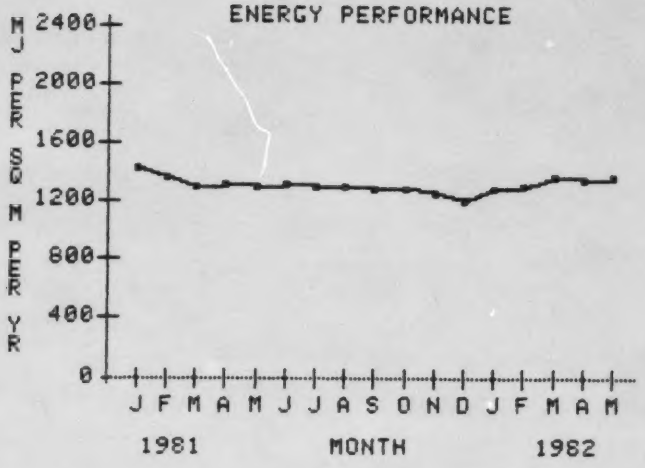
1981
MONTH
1982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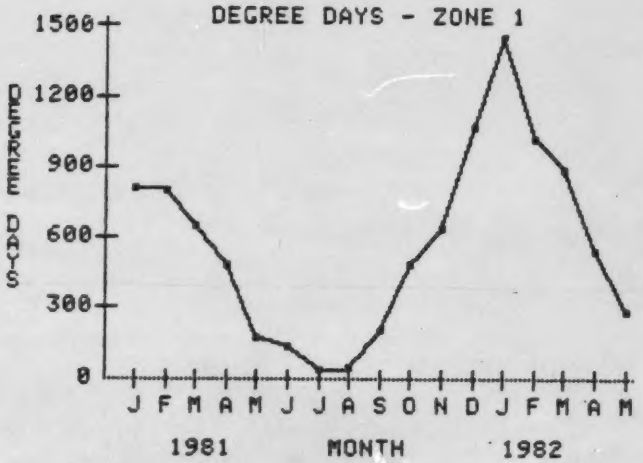
MONTH
1982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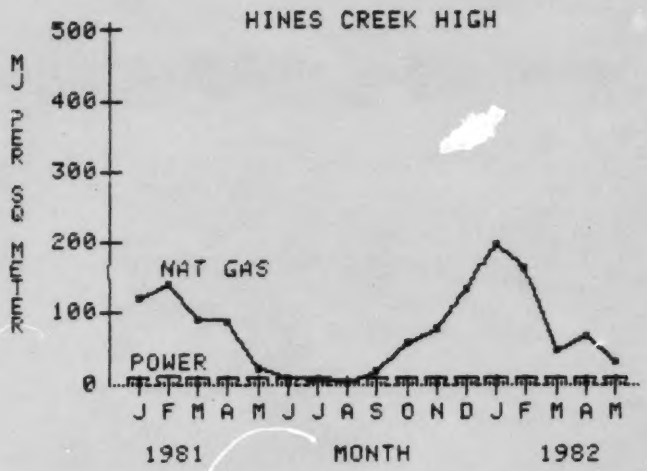
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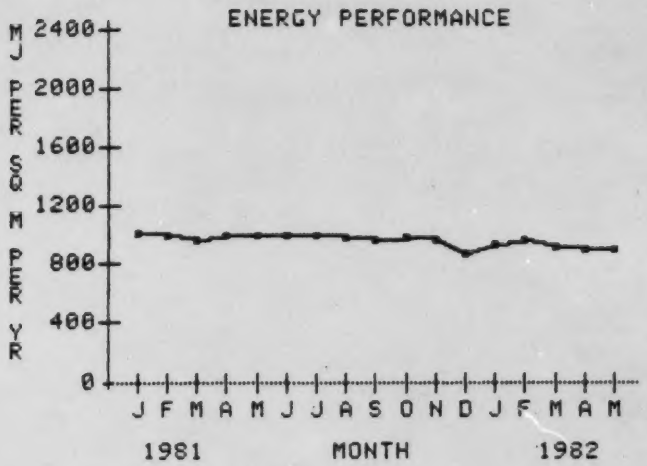
1981
MONTH
1982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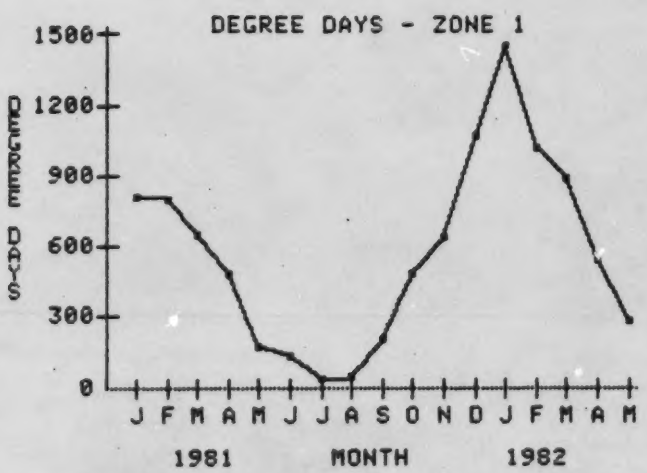
MONTH
1982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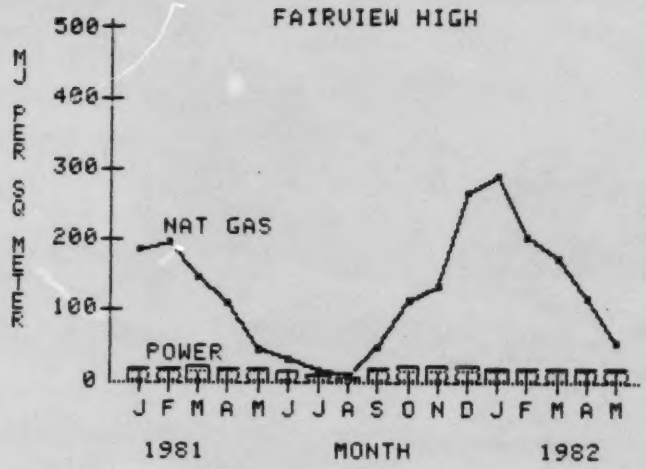
1981
MONTH
1982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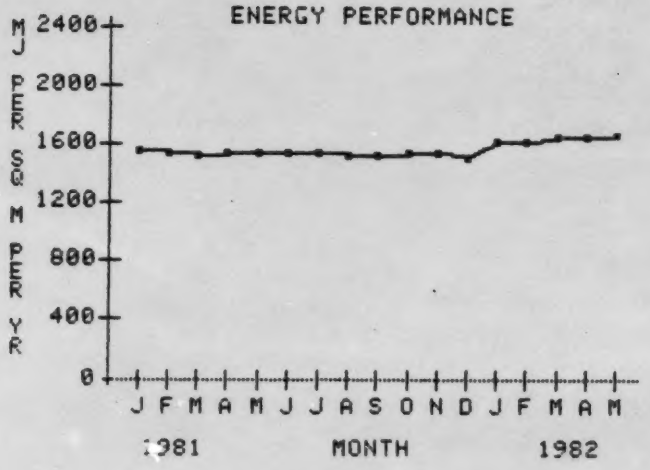
1981
MONTH
1982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MONTH
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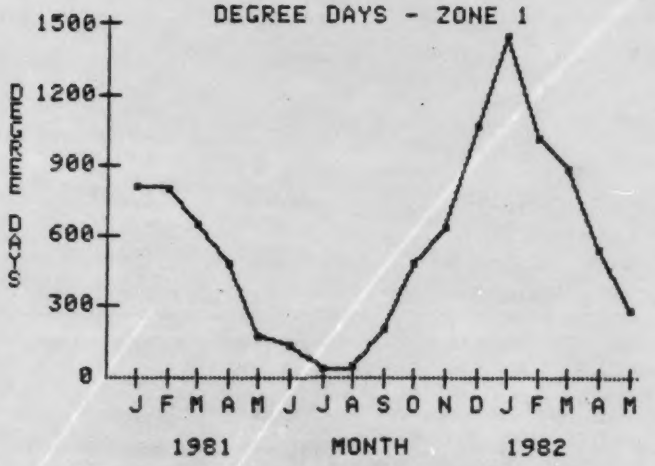
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MONTH
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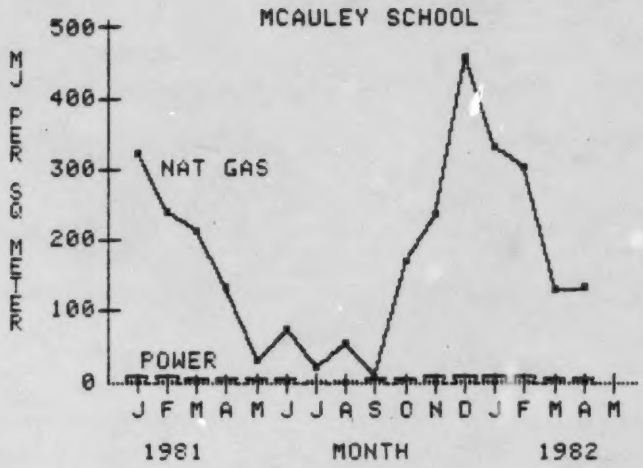
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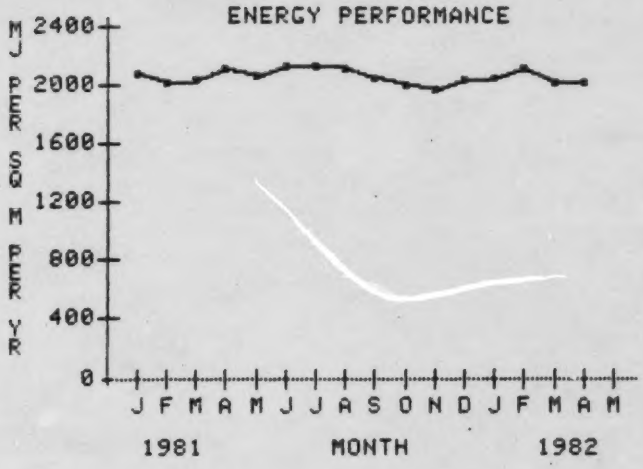
1981
MONTH
1982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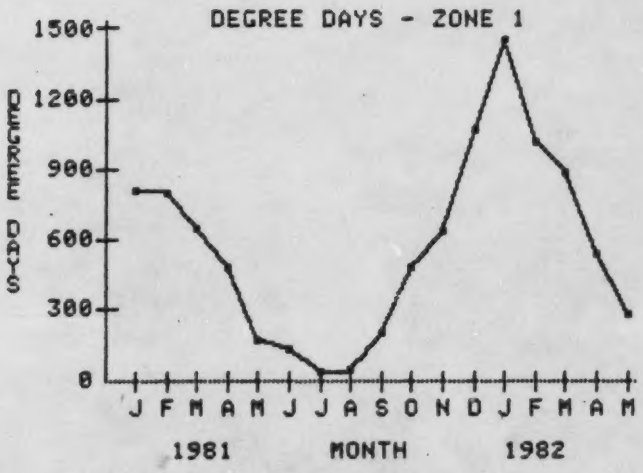
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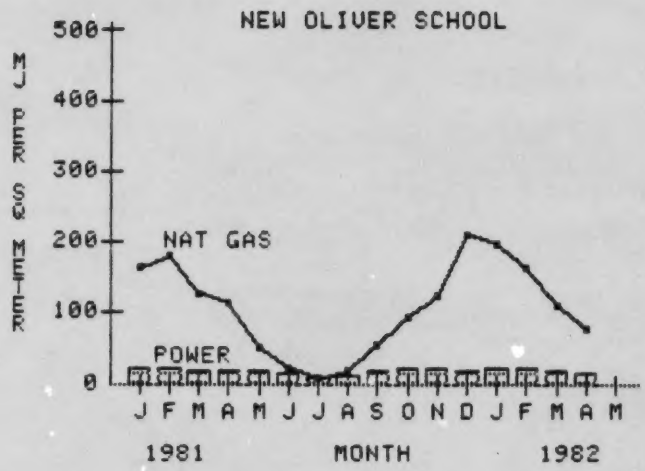
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POWER
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1981
MONTH
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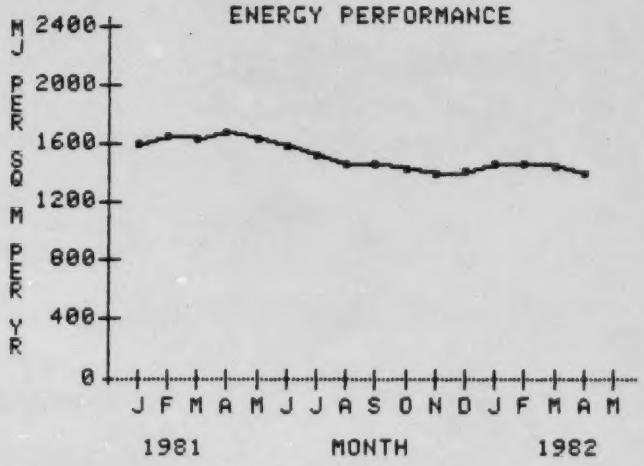
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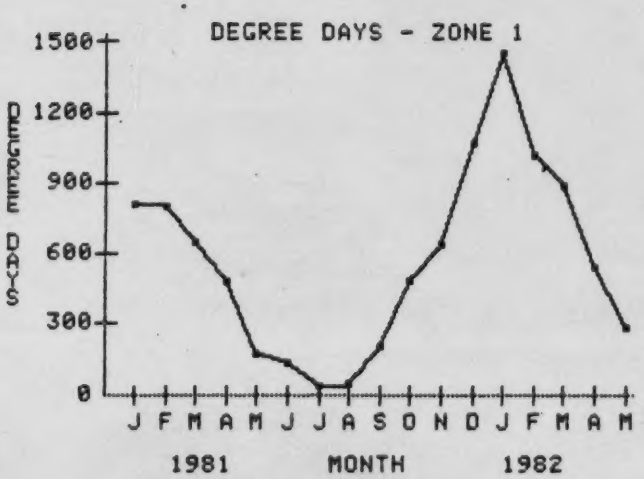
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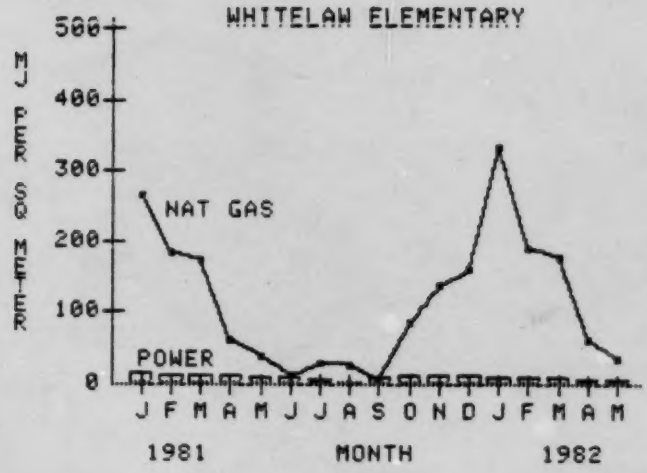
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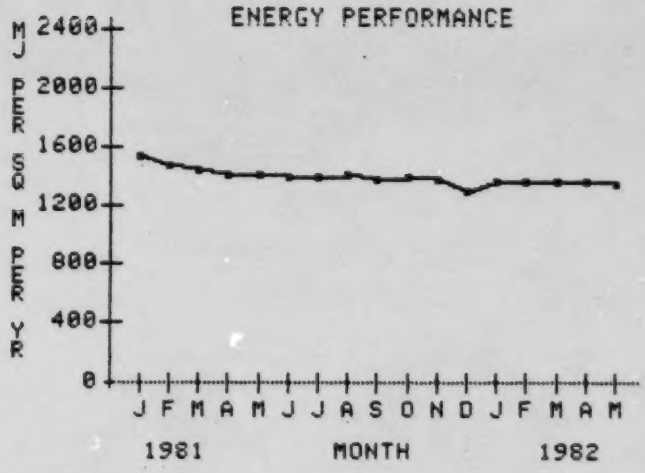
1981
MONTH
1982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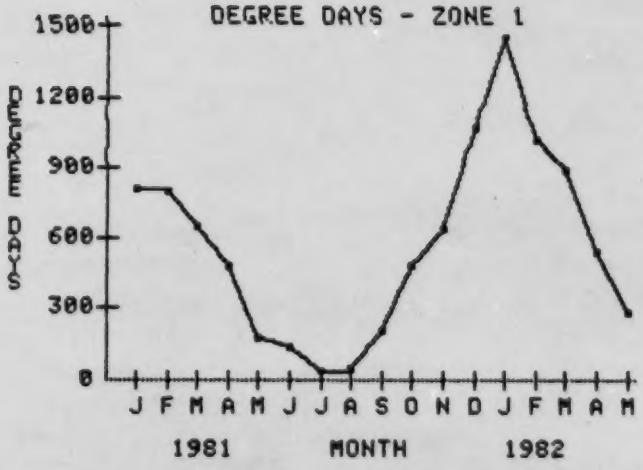
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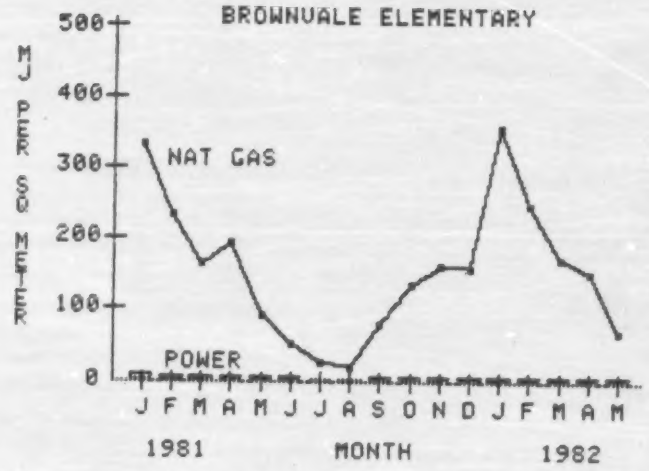
1982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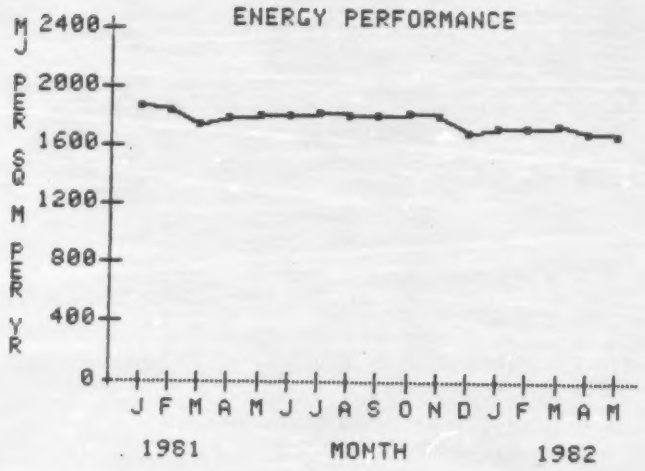
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MONTH
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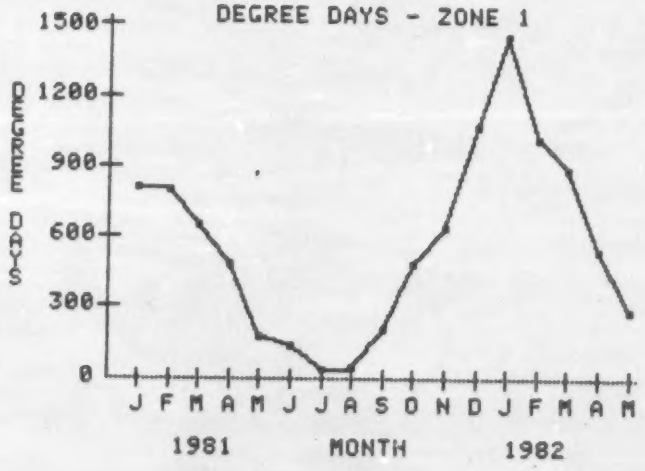
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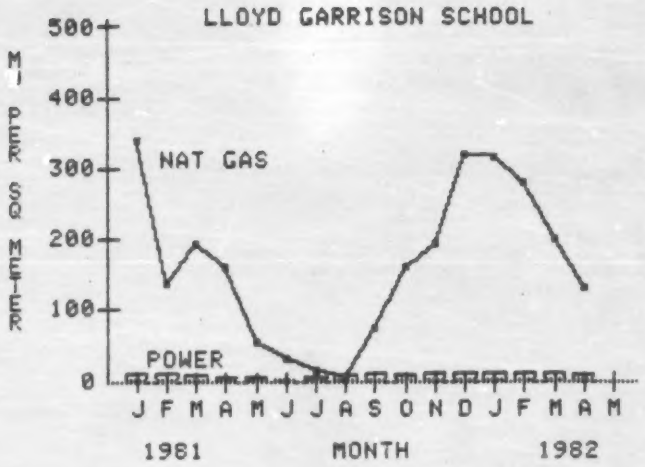
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1981
MONTH
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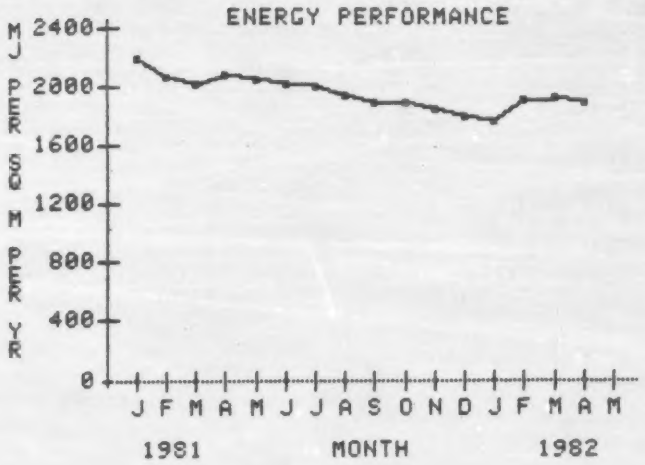
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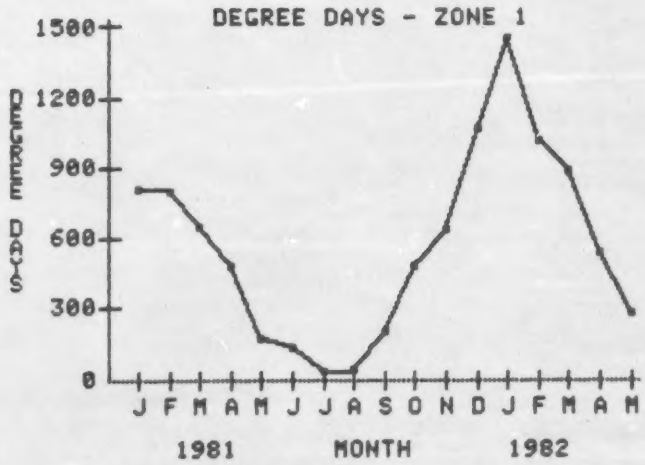
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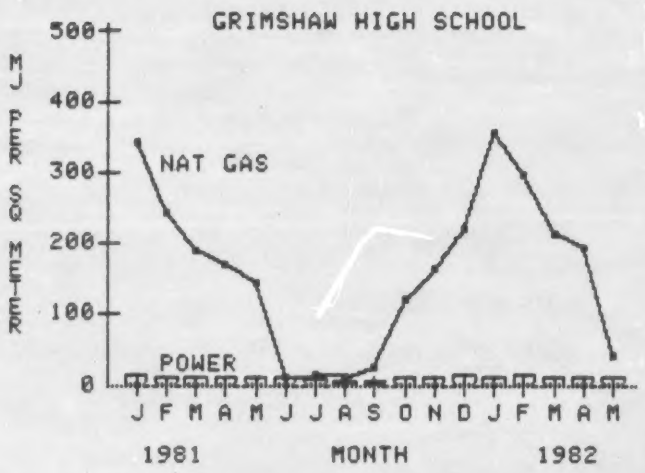
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POWER
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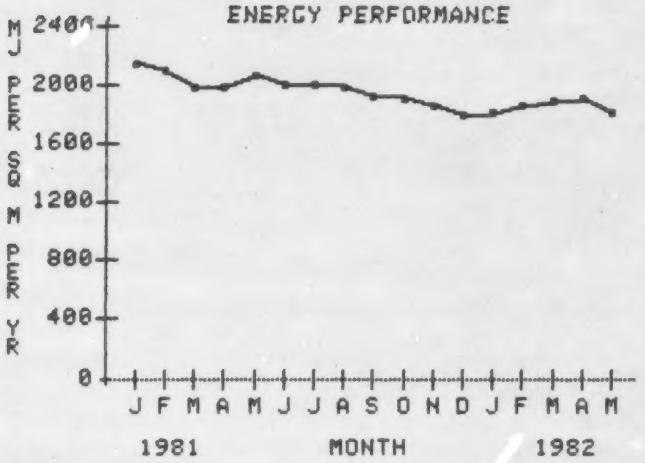
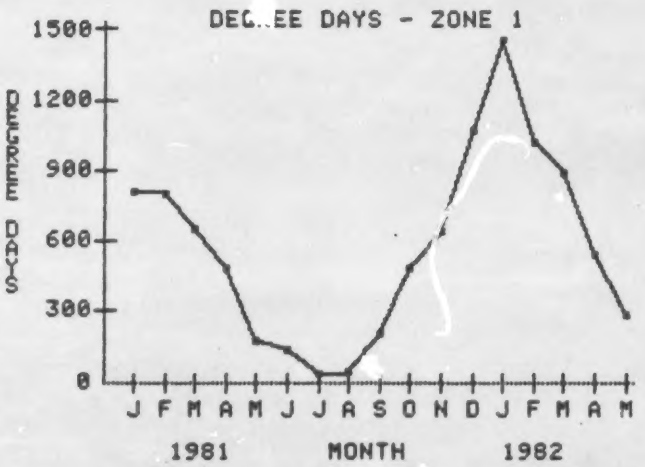
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 1
DEGREE DAYS
1500
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600
300
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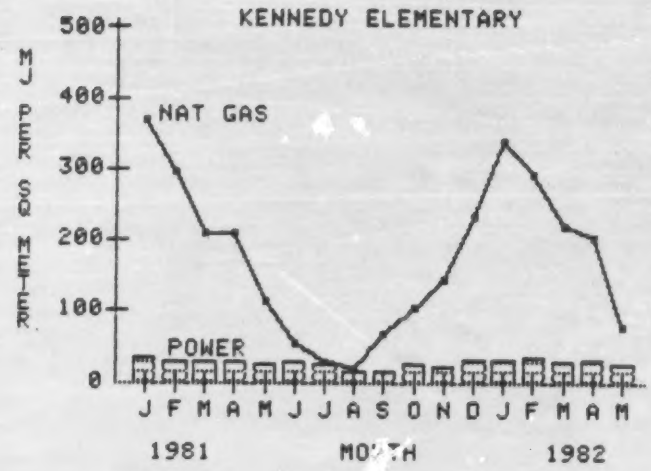
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


KENNEDY ELEMENTARY
MJ PER SQ METER
500
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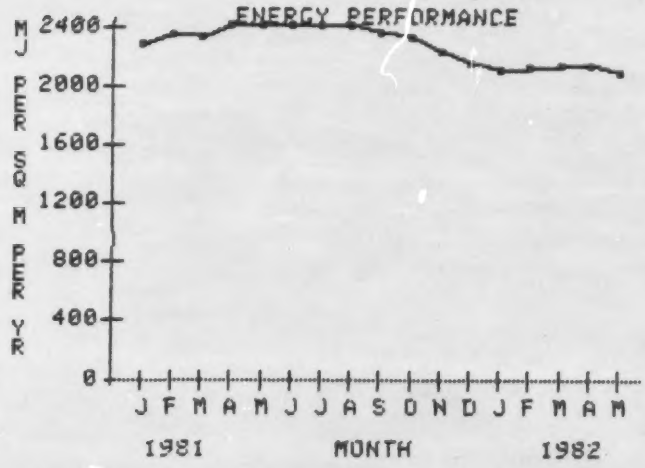
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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2000
1600
1200
800
400
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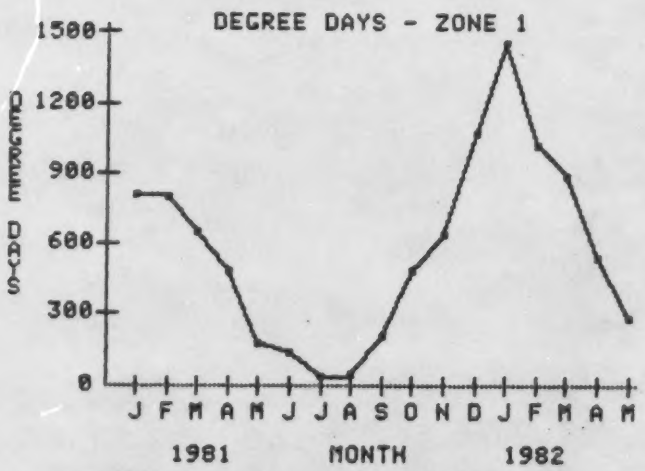
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 1
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1500
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300
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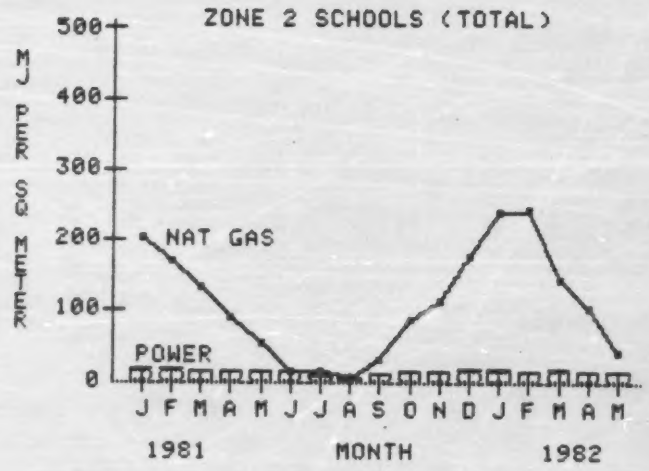
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ZONE 2 SCHOOLS (TOTAL)
MJ PER SQ METER
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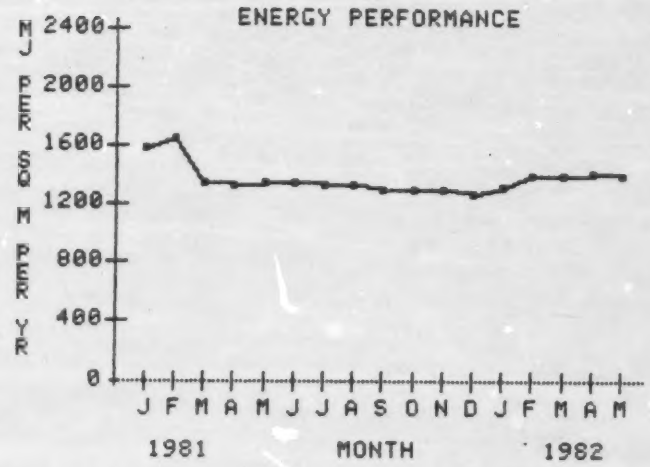
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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2000
1600
1200
800
400
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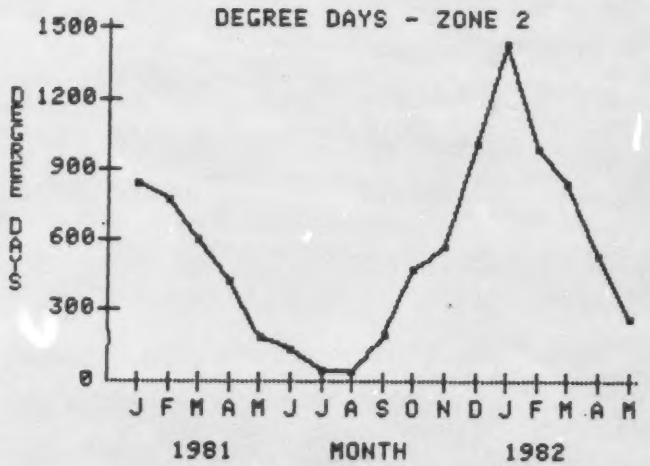
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
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300
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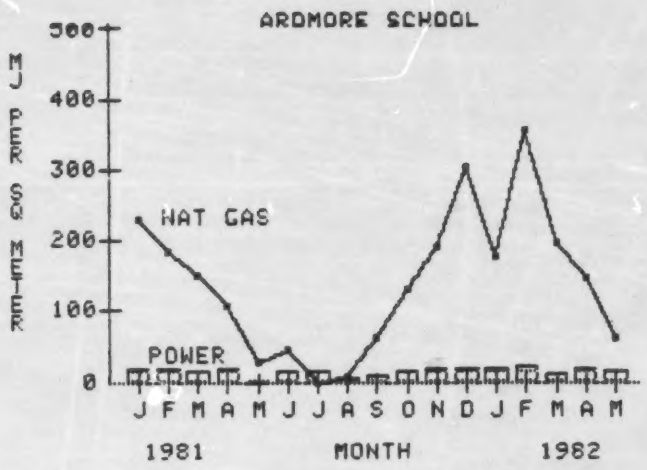
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ARDMORE SCHOOL
MJ PER SQ METER
500
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300
200
100
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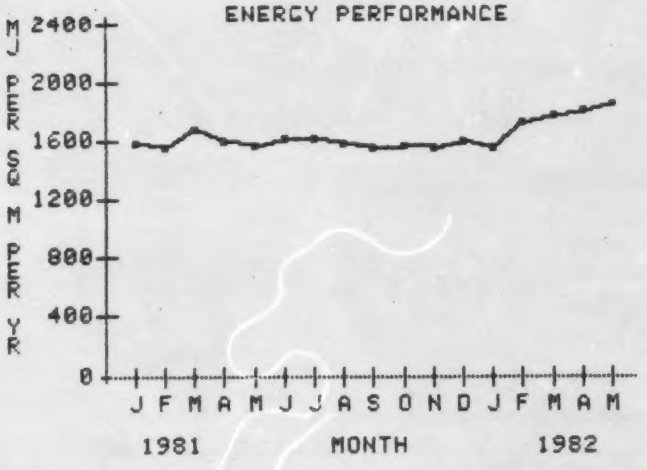
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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2000
1600
1200
800
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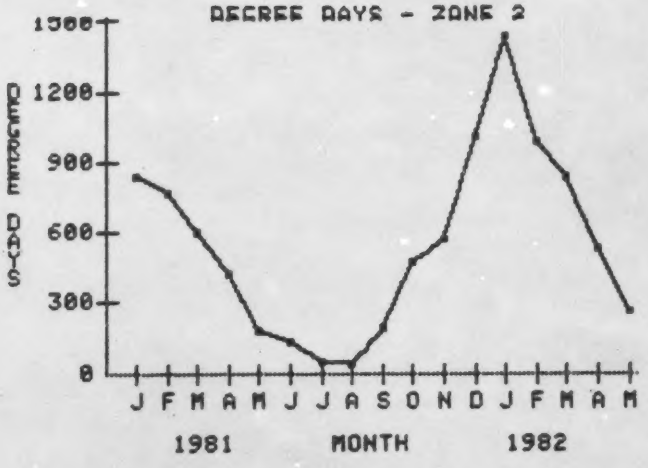
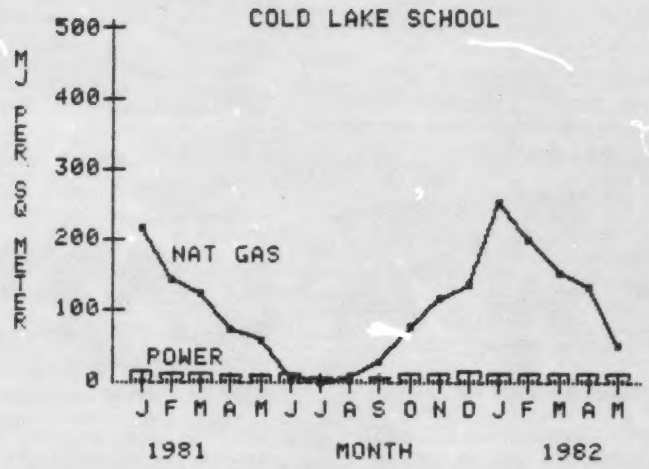
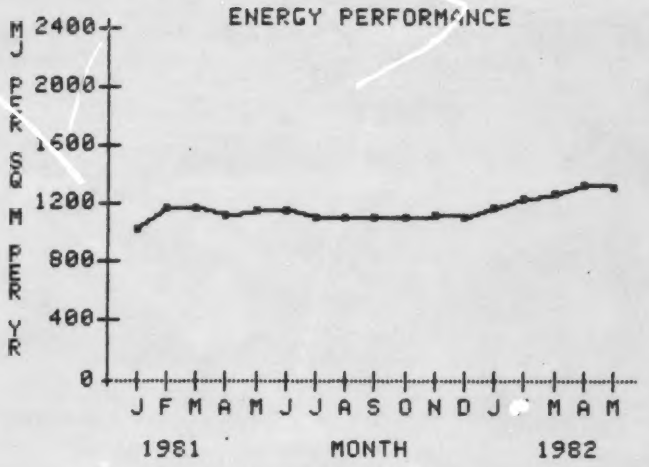
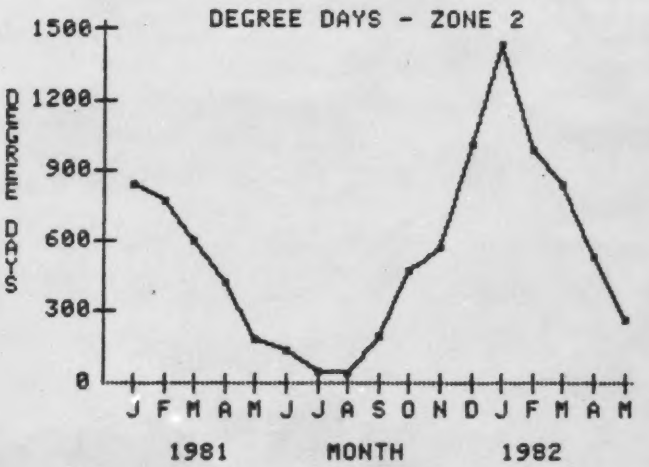
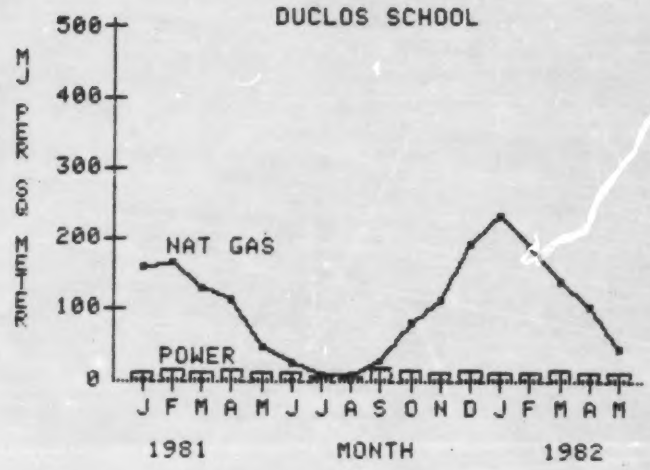
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


COLD LAKE SCHOOL
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DUCLOS SCHOOL
MJ PER SQ METER
500
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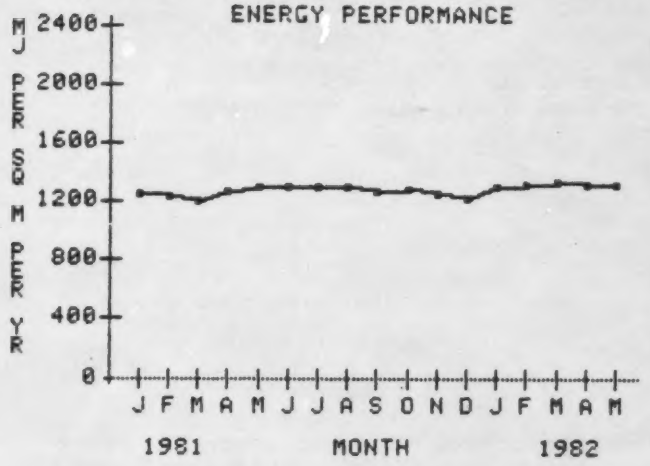
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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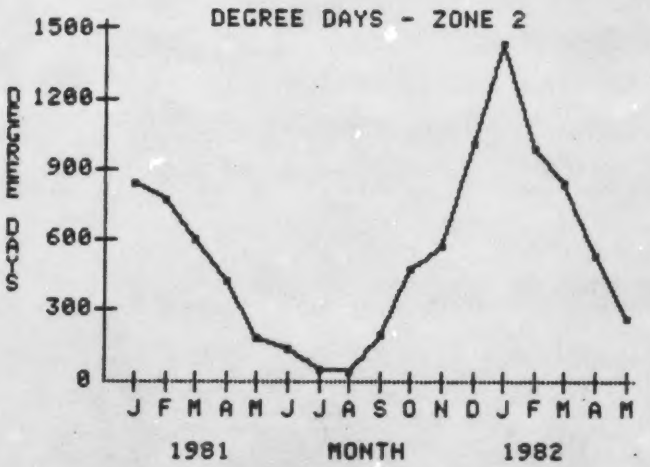
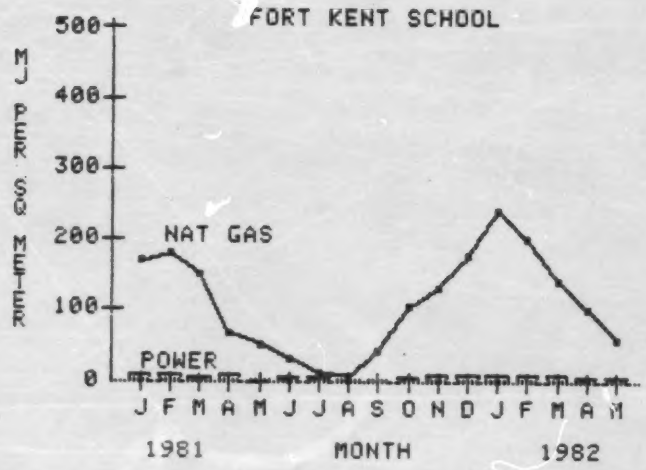
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


FORT KENT SCHOOL
MJ PER SQ METER
500
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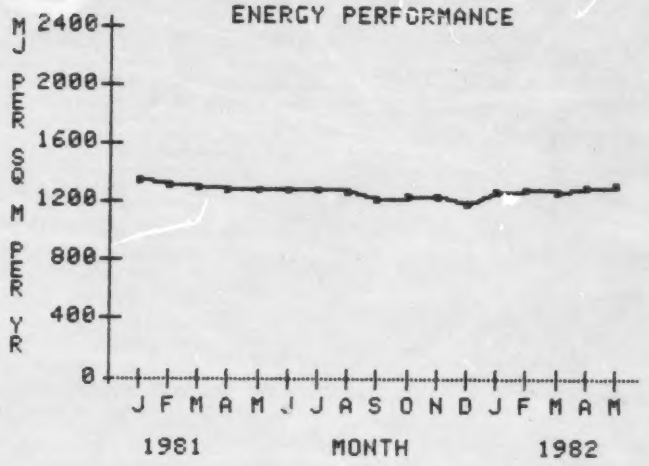
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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2000
1600
1200
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400
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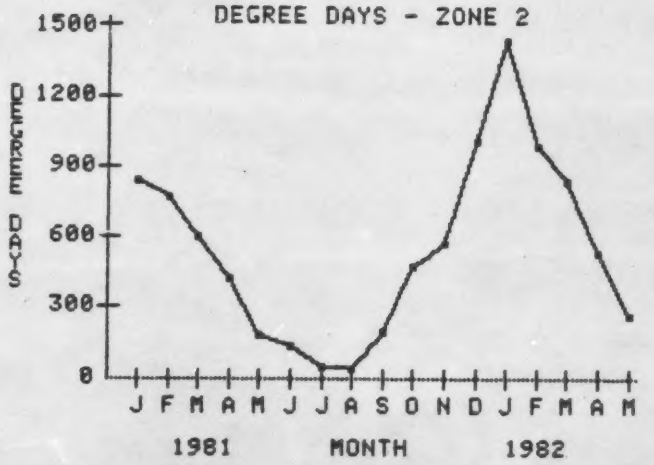
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
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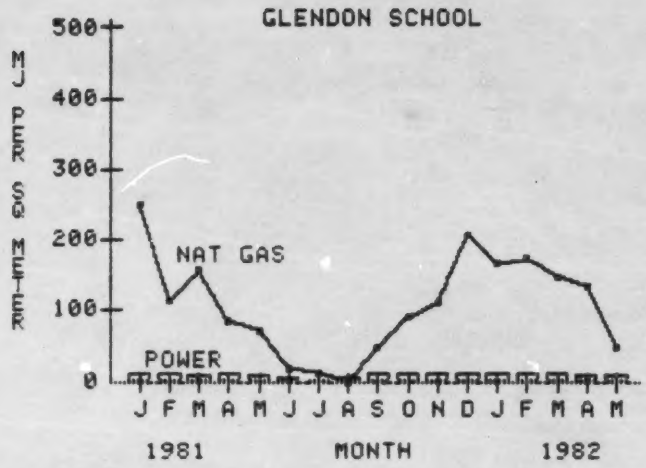
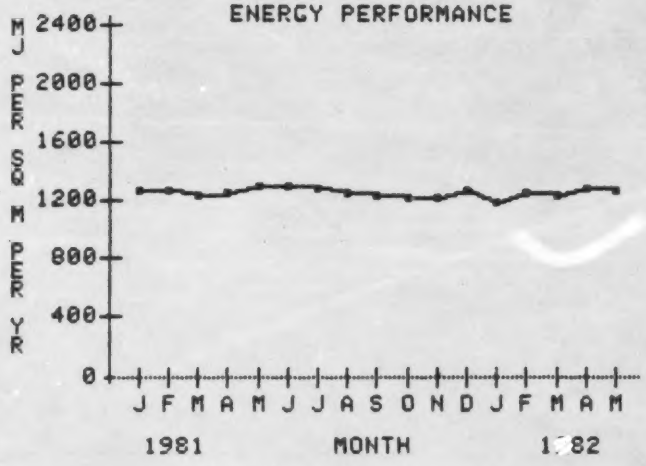
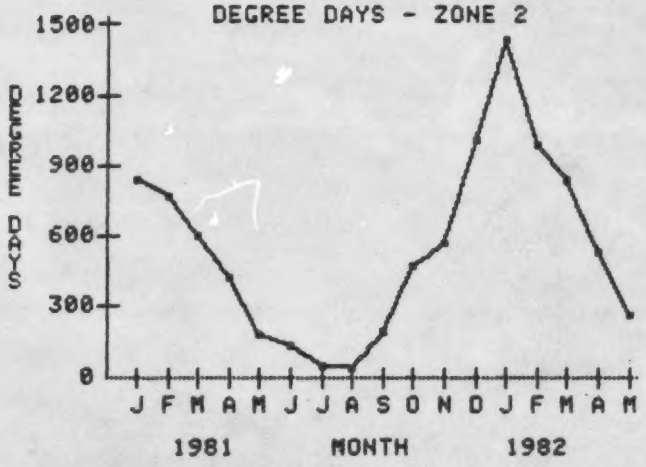
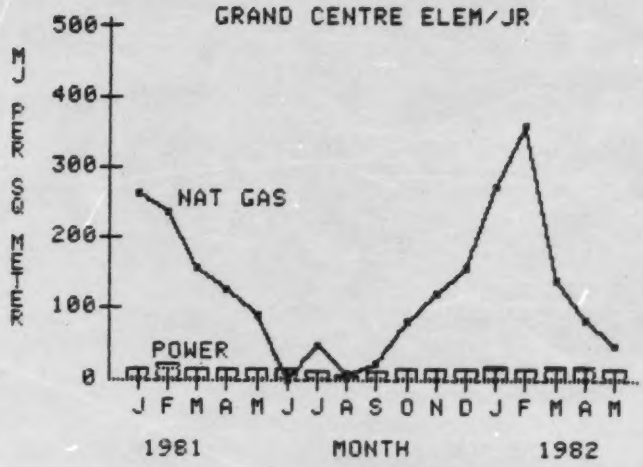
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


GLENDON SCHOOL
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


GRAND CENTRE ELEM/JR
MJ PER SQ METER
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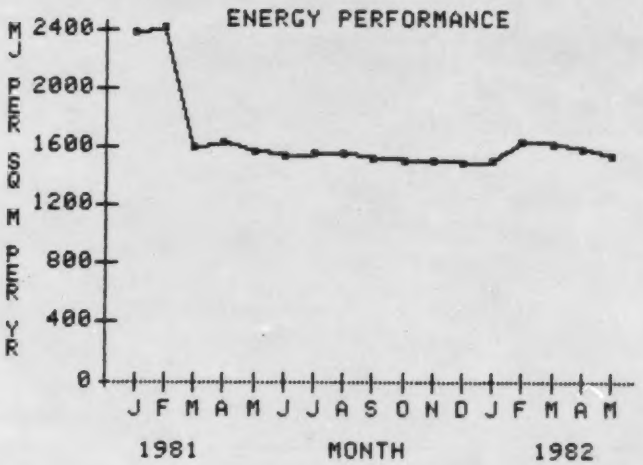
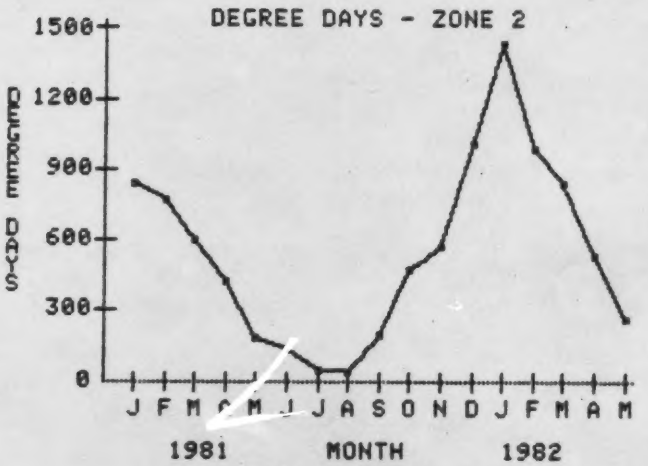
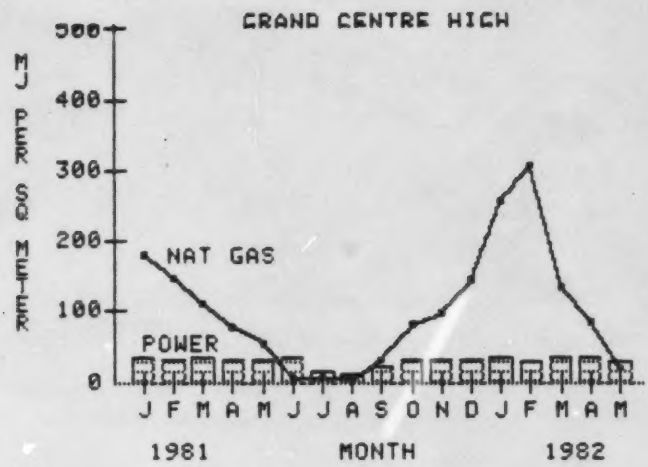
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


GRAND CENTRE HIGH
MJ PER SQ METER
500
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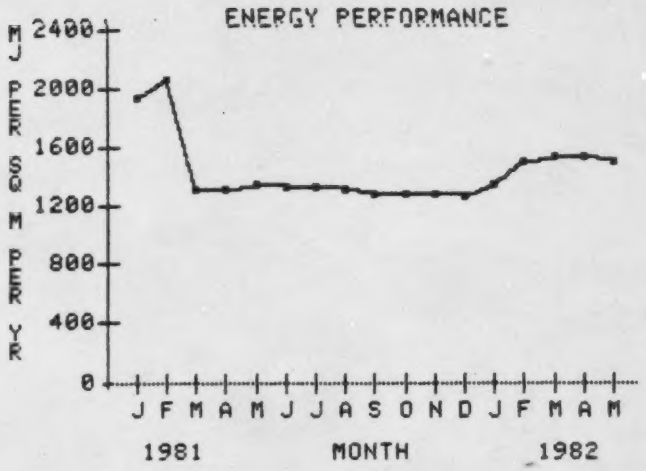
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
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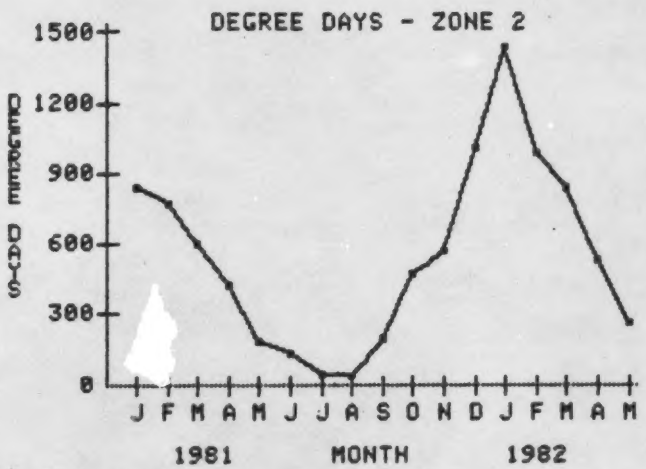
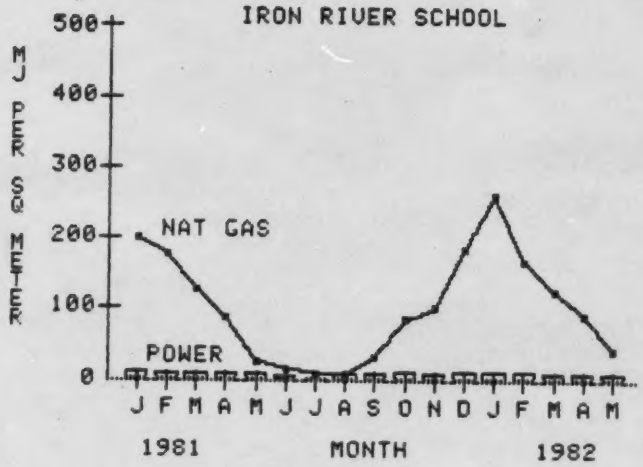
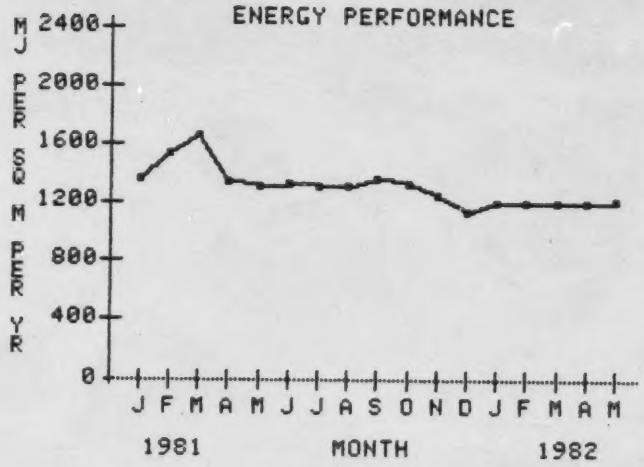
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


IRON RIVER SCHOOL
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
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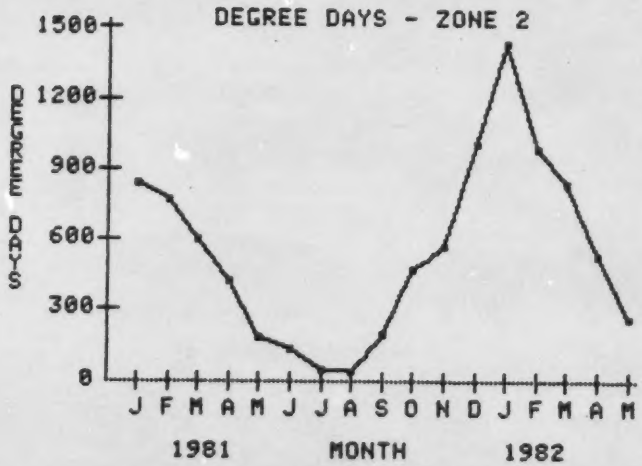
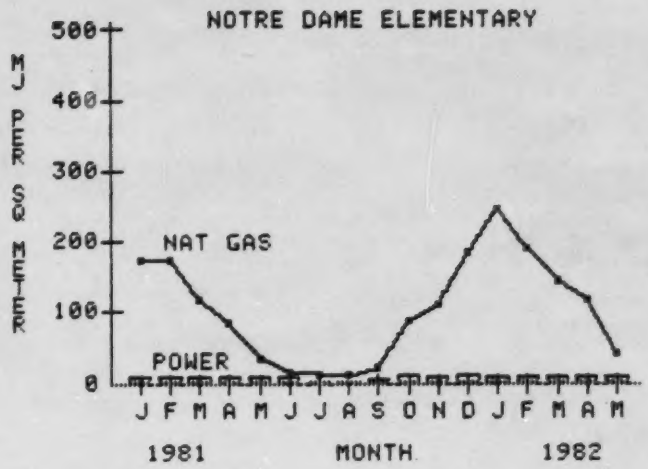
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


NOTRE DAME ELEMENTARY
MJ PER SQ METER
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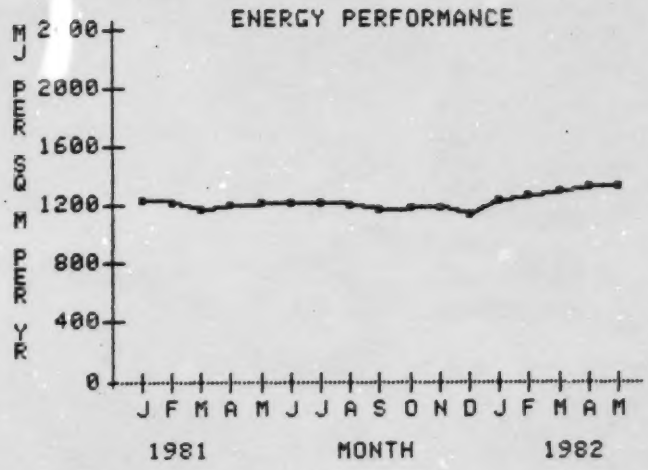
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2000
1600
1200
800
400
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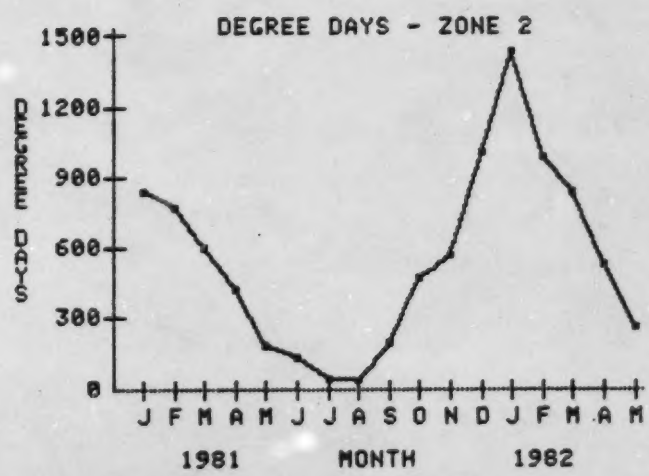
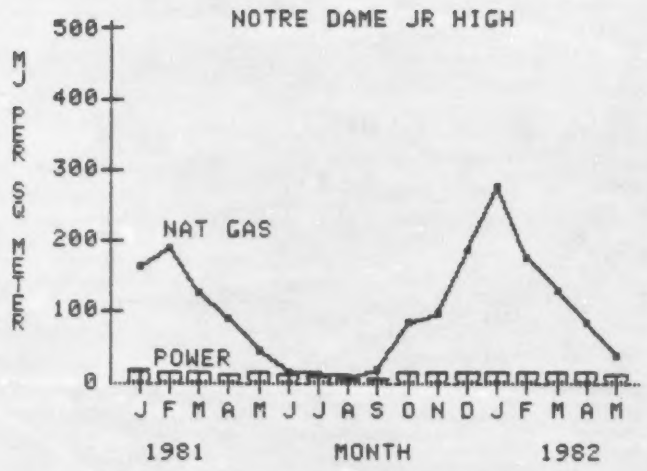
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


NOTRE DAME JR HIGH
MJ PER SQ METER
500
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100
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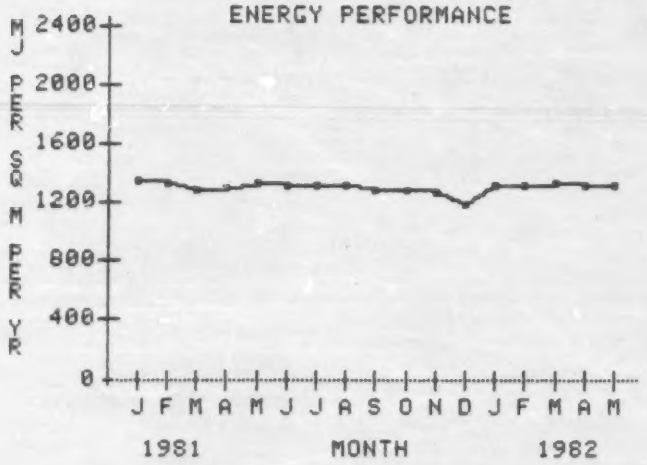
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
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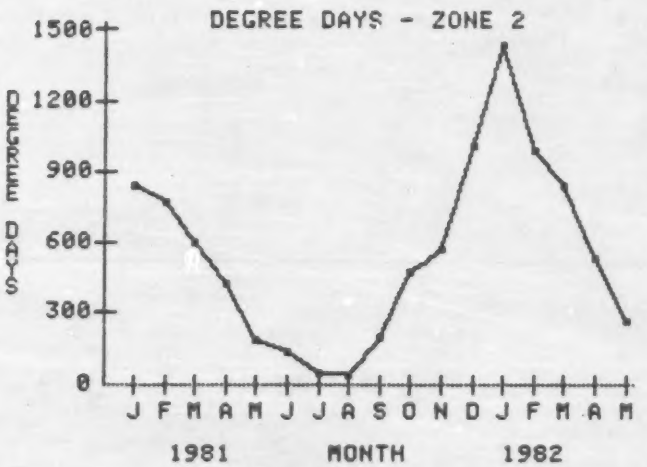
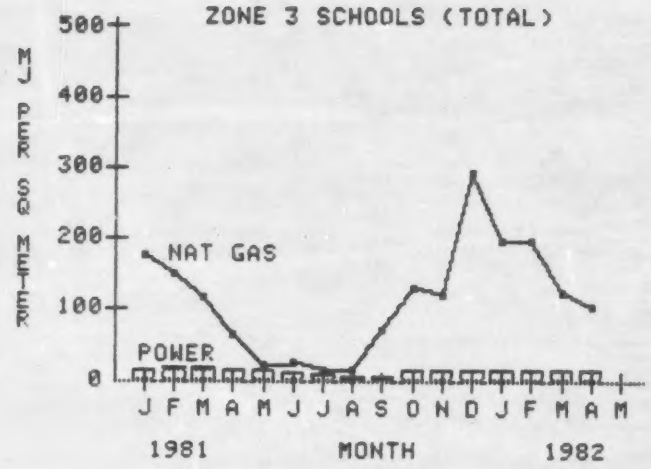
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 2
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ZONE 3 SCHOOLS (TOTAL)
MJ PER SQ METER
500
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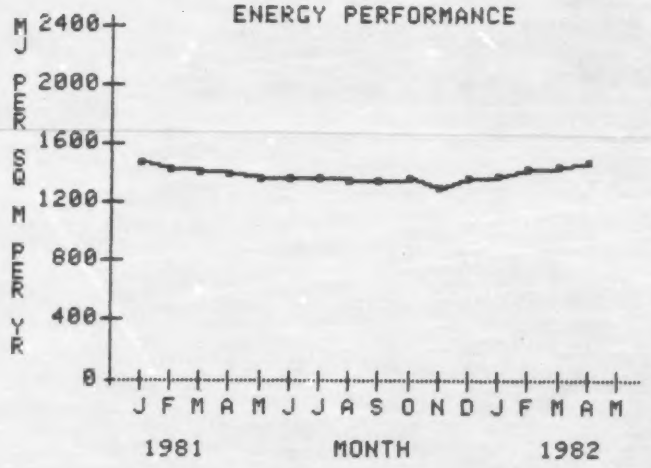
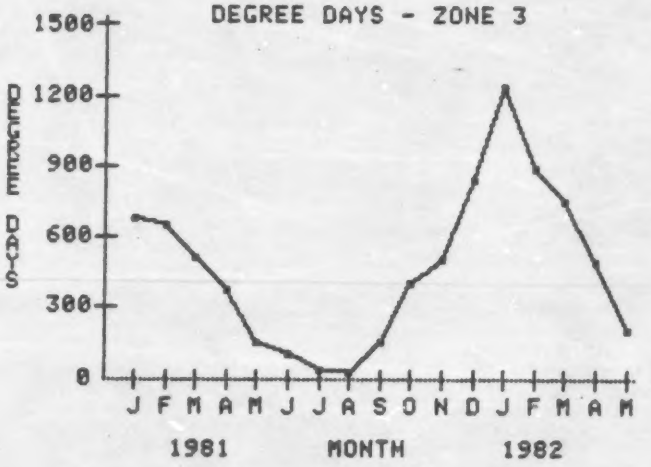
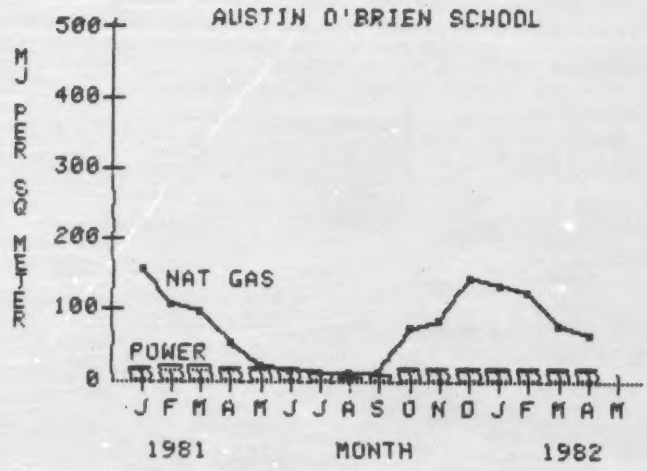
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


AUSTIN O'BRIEN SCHOOL
MJ PER SQ METER
500
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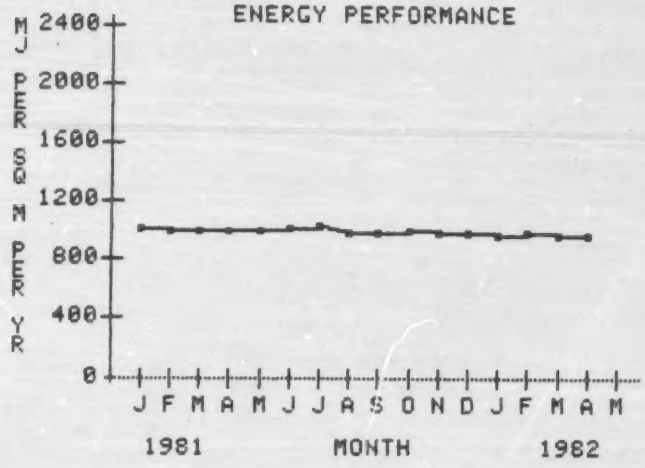
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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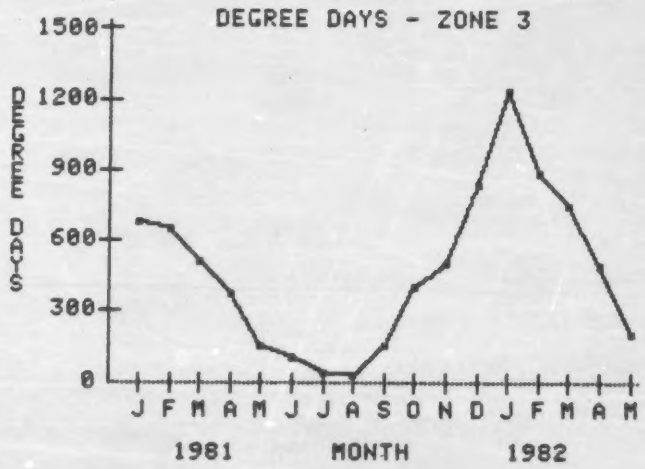
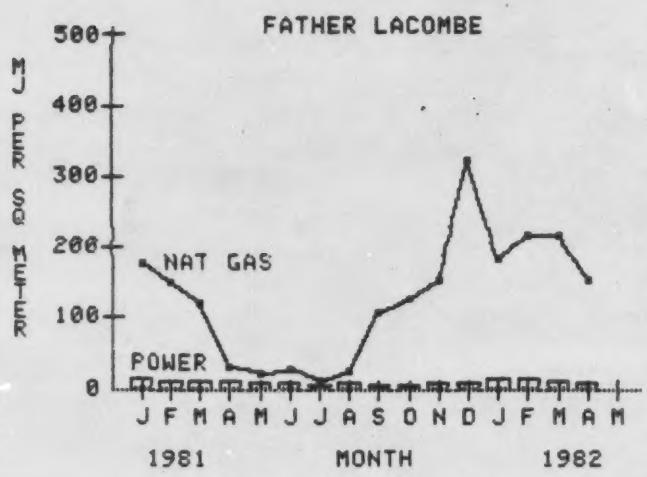
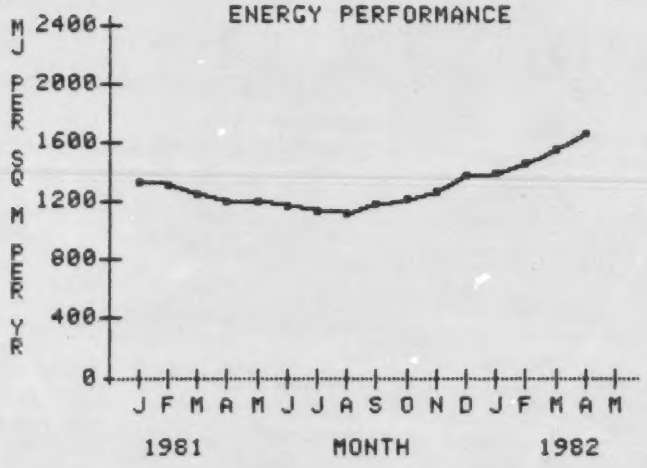
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


FATHER LACOMBE
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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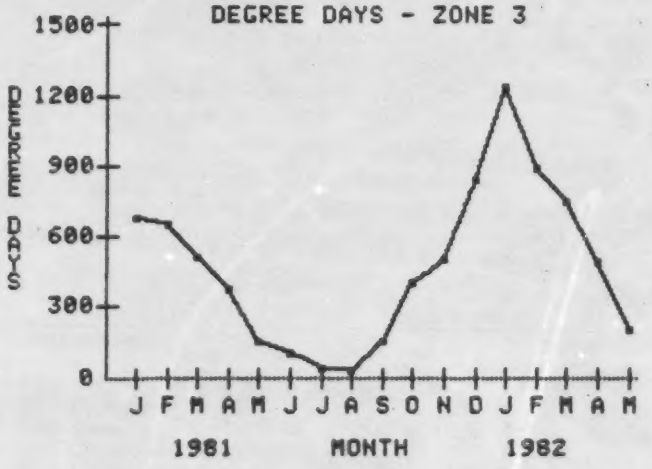
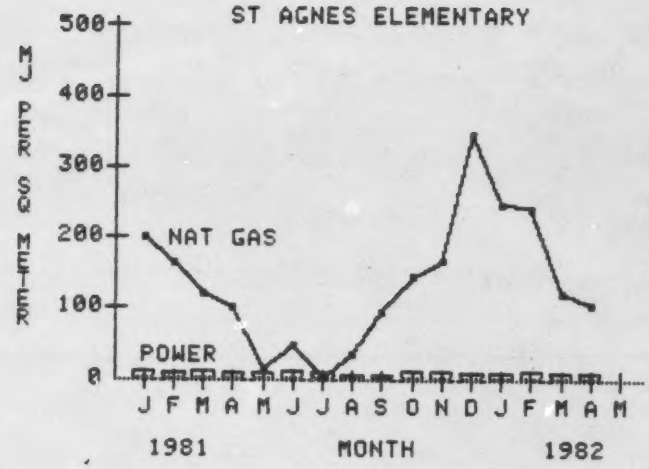
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ST AGNES ELEMENTARY
MJ PER SQ METER
500
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300
200
100
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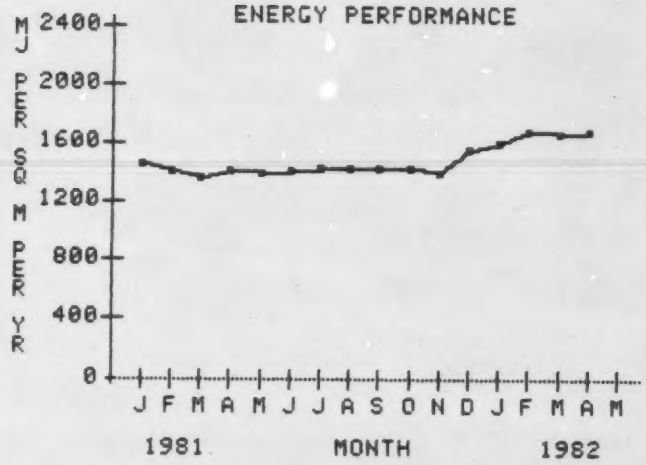
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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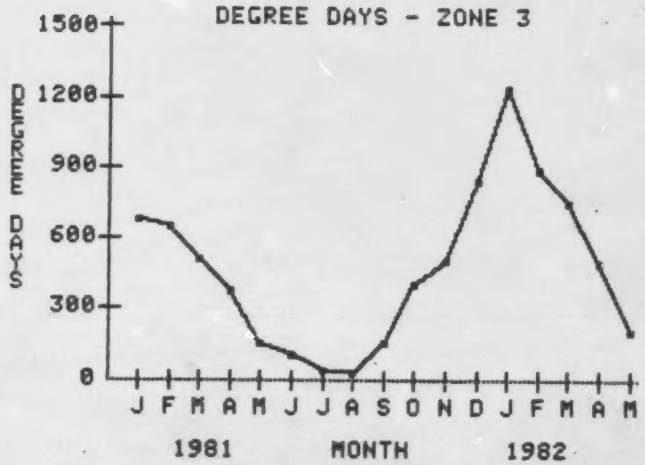
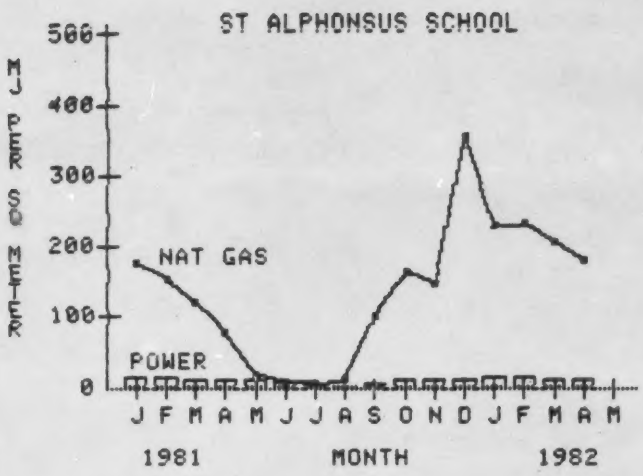
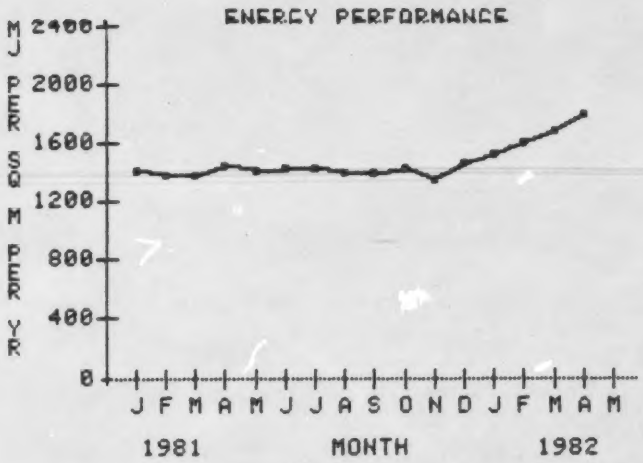
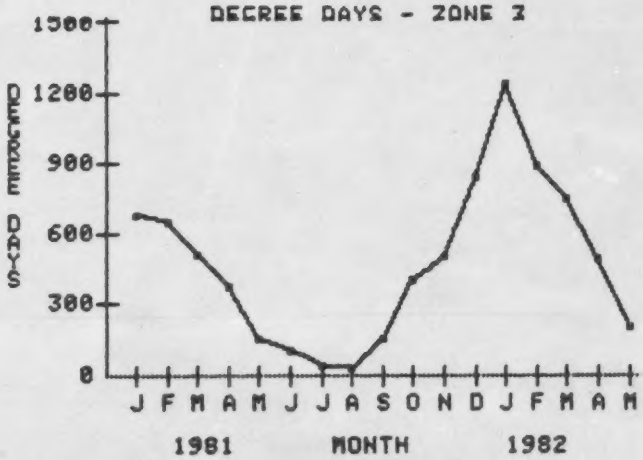
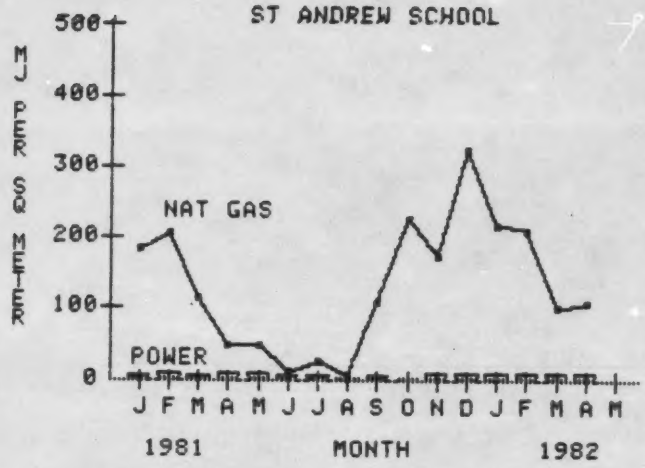
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

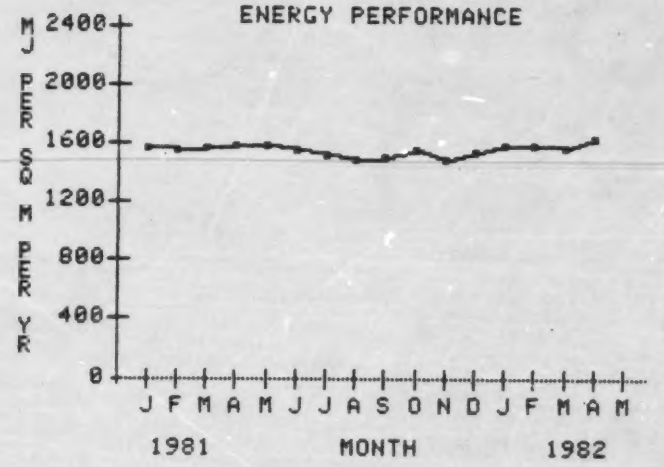

DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

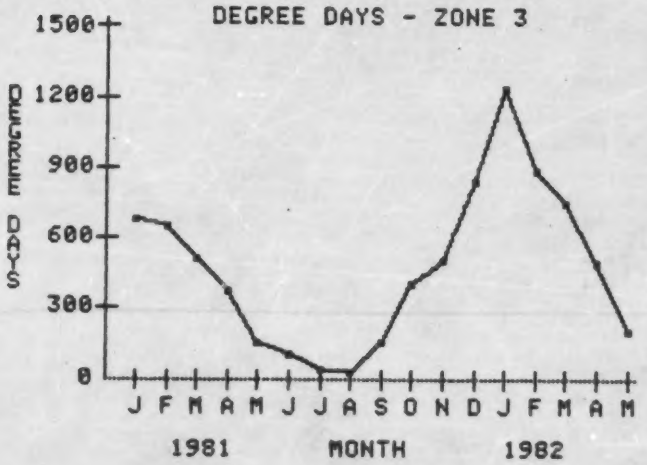

ST ALPHONSUS SCHOOL
MJ PER SQ M PER YR
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

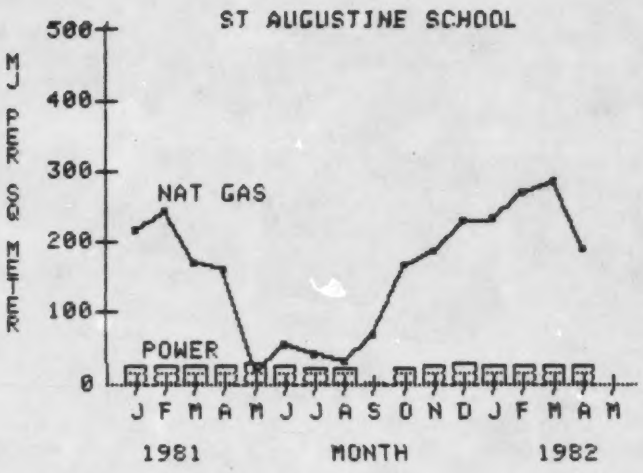

ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ST ANDREW SCHOOL
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ST AUGUSTINE SCHOOL
MJ PER SQ METER
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200
100
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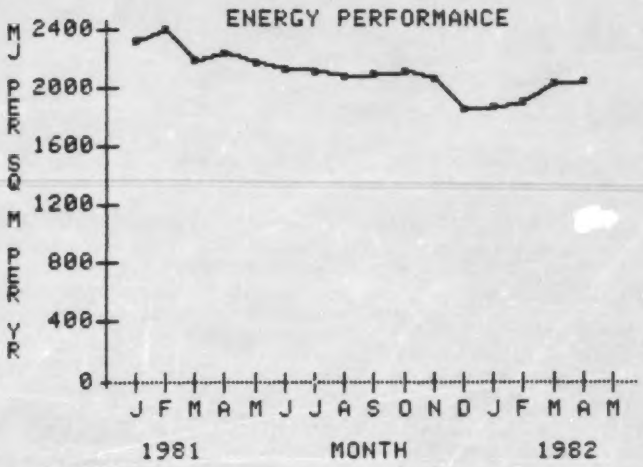
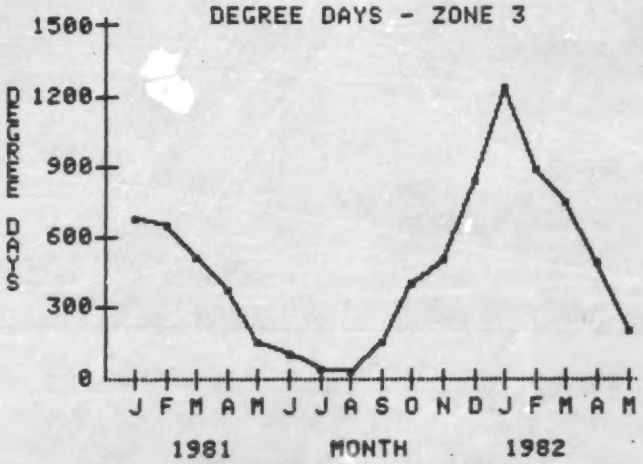
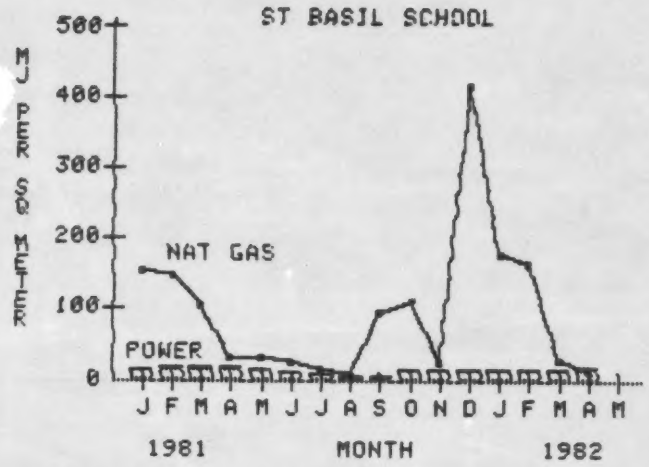
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ST BASIL SCHOOL
MJ PER SQ METER
500
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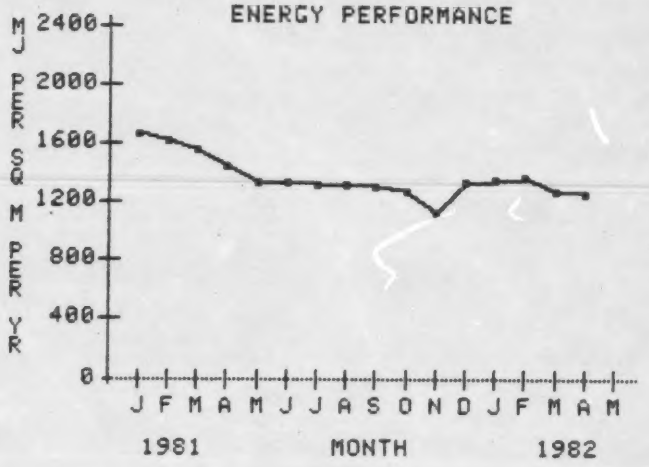
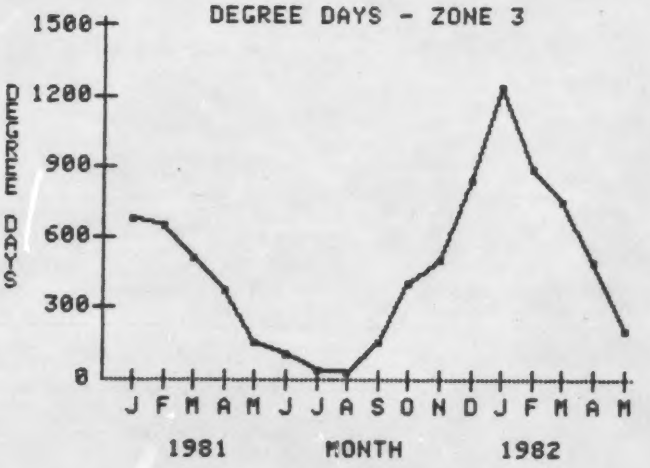
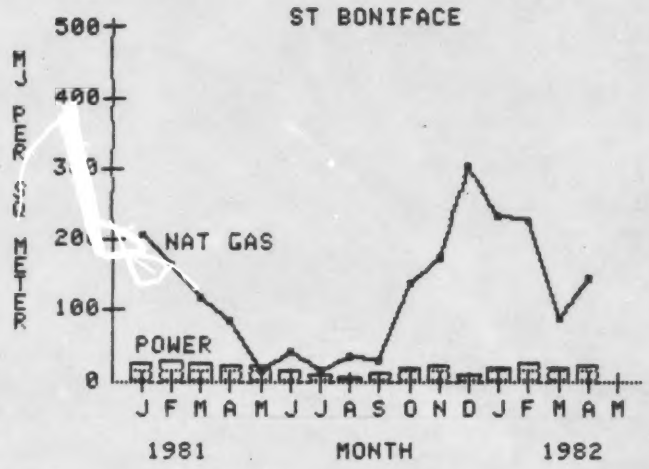
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ST BONIFACE
MJ PER SQ METER
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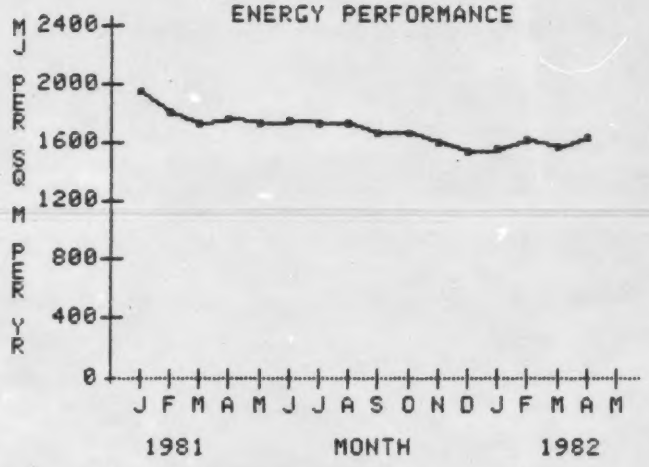
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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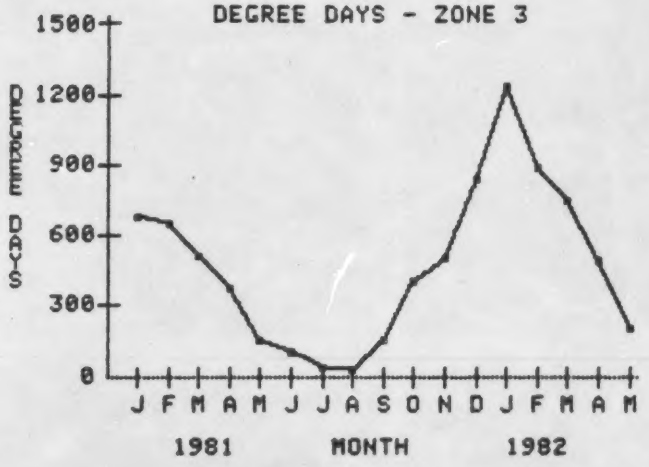
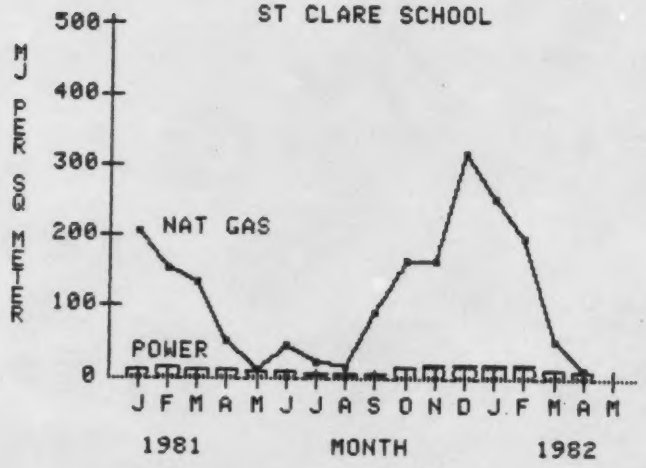
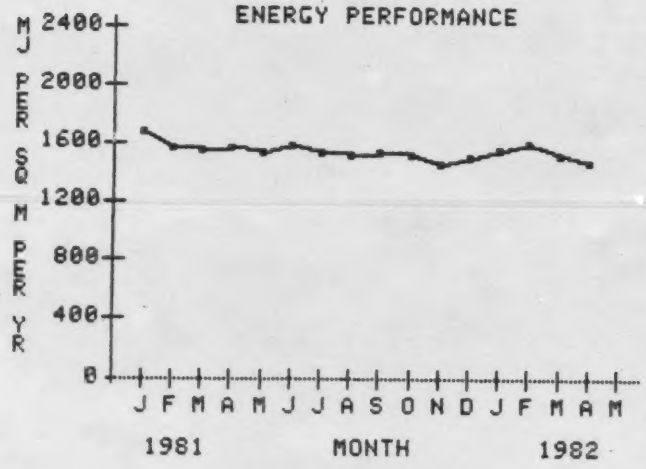
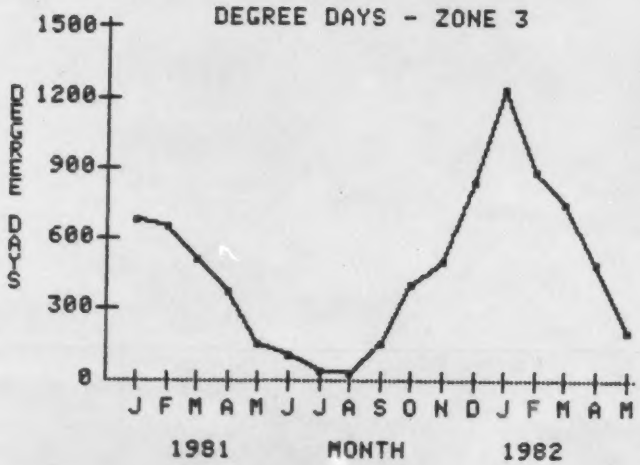
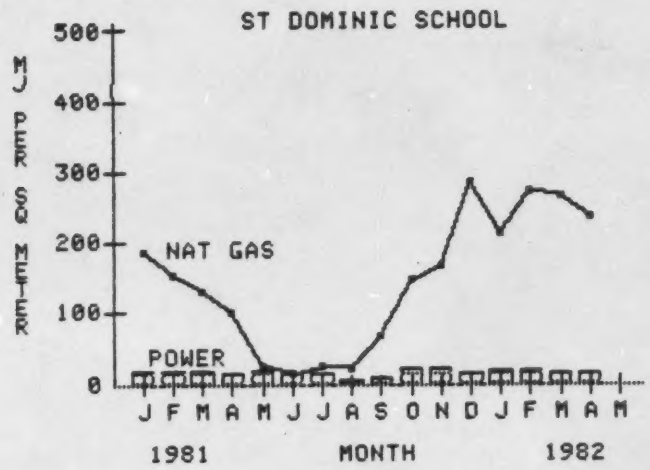
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ST CLARE SCHOOL
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ST DOMINIC SCHOOL
MJ PER SQ METER
500
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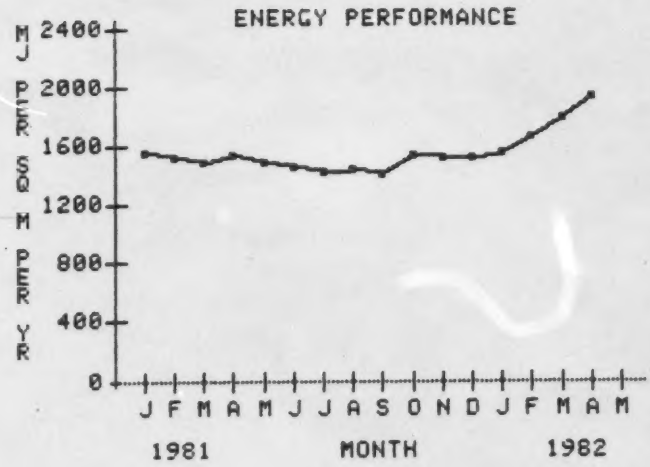
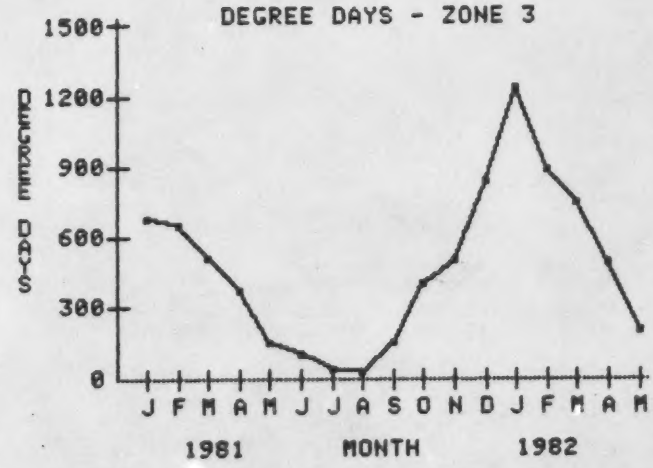
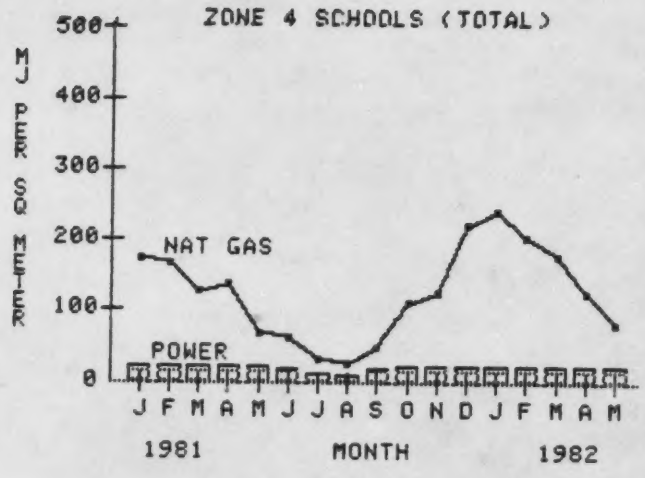
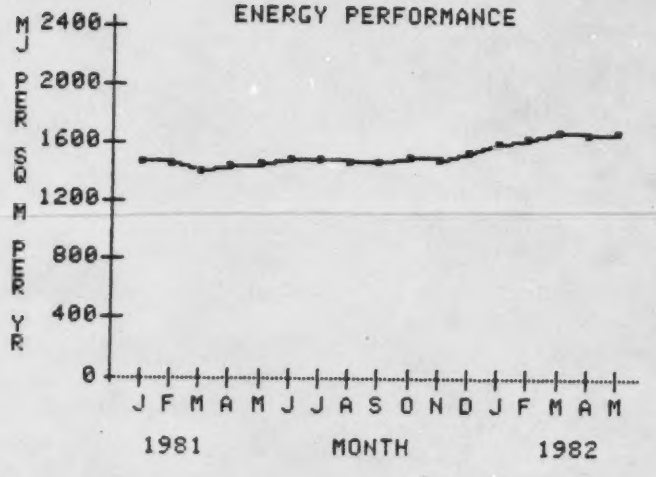
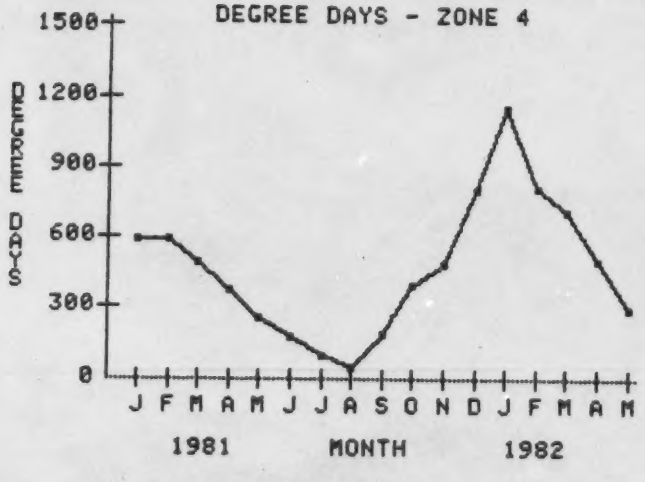
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

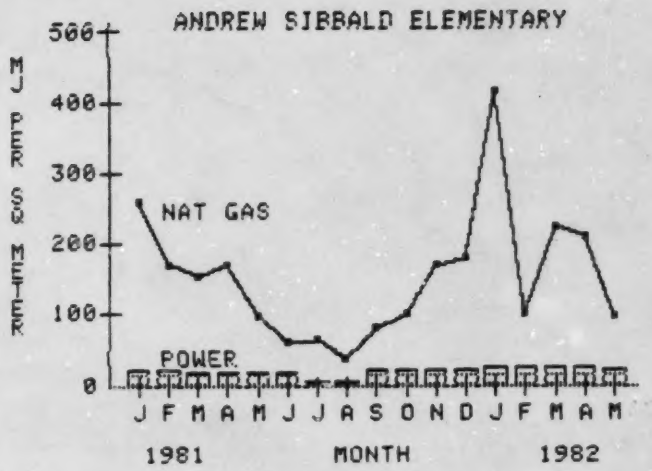

ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

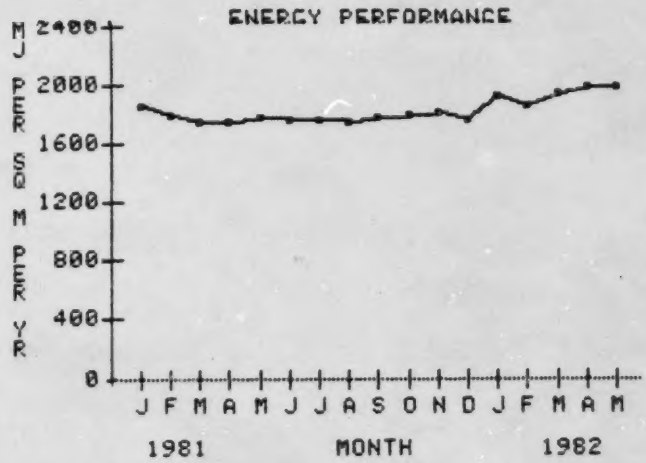

DEGREE DAYS - ZONE 3
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

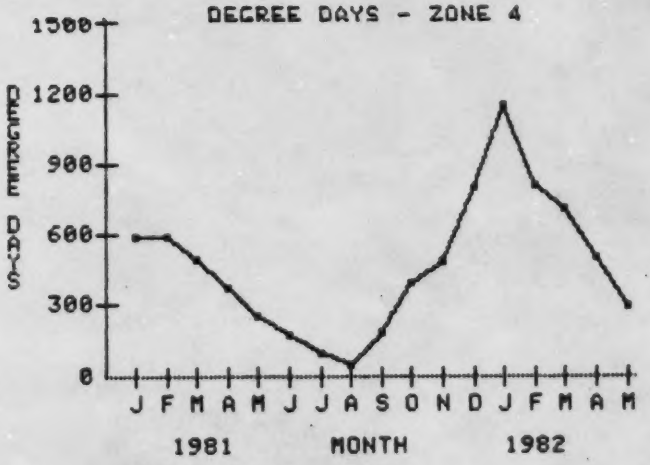

ZONE 4 SCHOOLS (TOTAL)
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ANDREW SIBBALD ELEMENTARY
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
1500
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600
300
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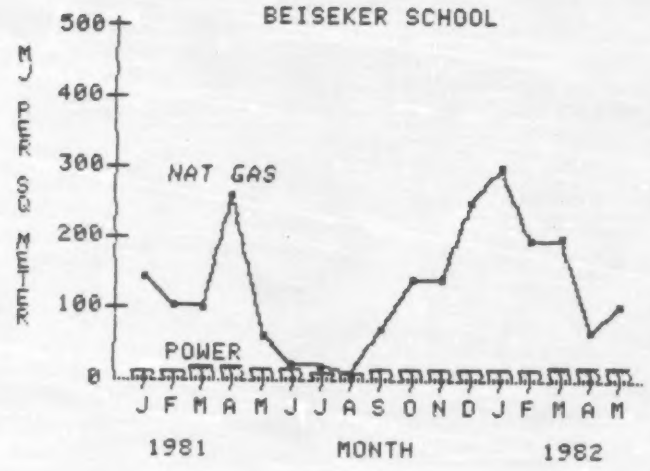
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


BEISEKER SCHOOL
MJ PER SQ METER
500
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200
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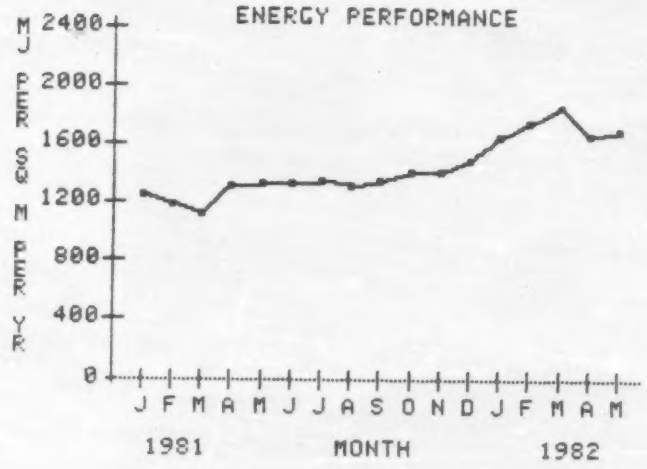
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
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1200
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400
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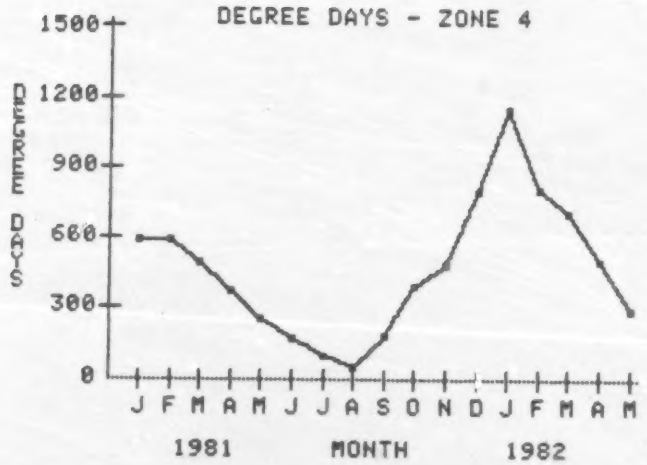
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
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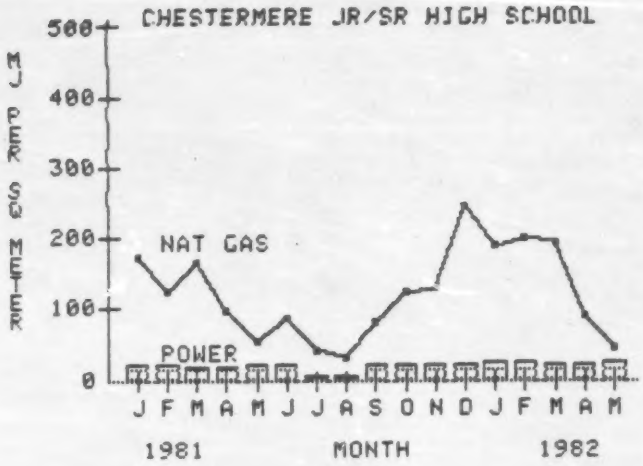
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


CHESTERMERE JR/SR HIGH SCHOOL
MJ PER SQ METER
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200
100
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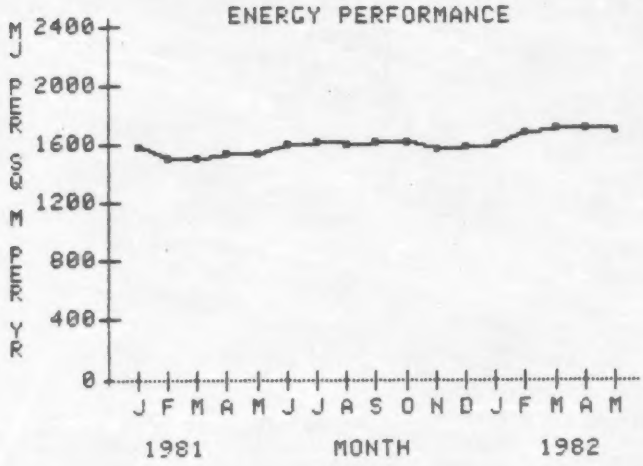
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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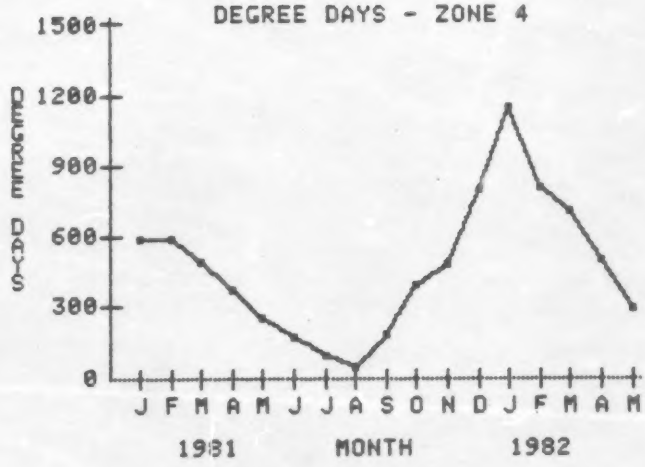
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
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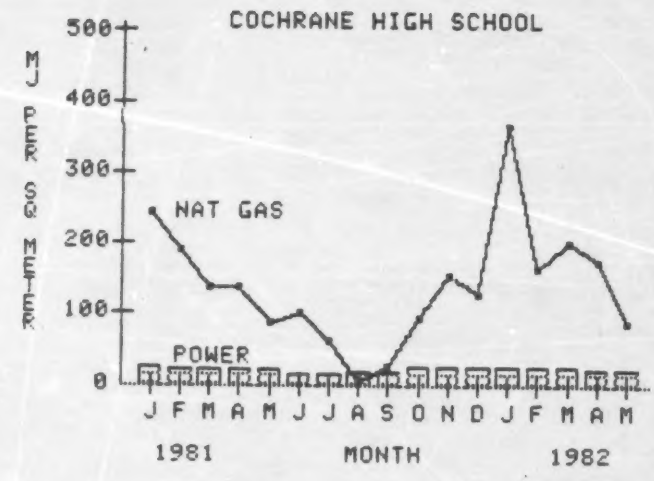
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


COCHRANE HIGH SCHOOL
MJ PER SQ METER
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200
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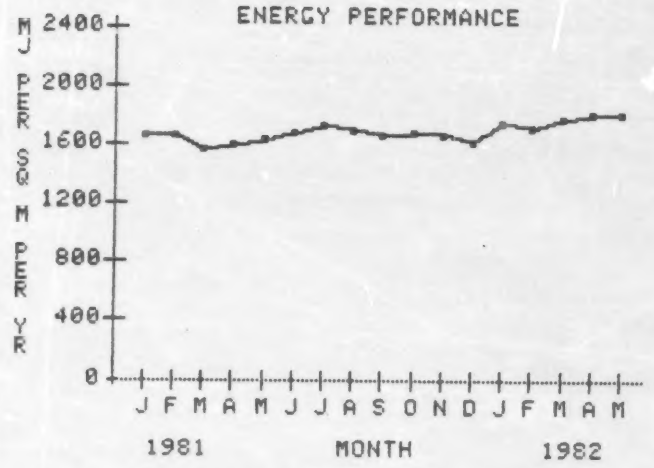
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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2000
1600
1200
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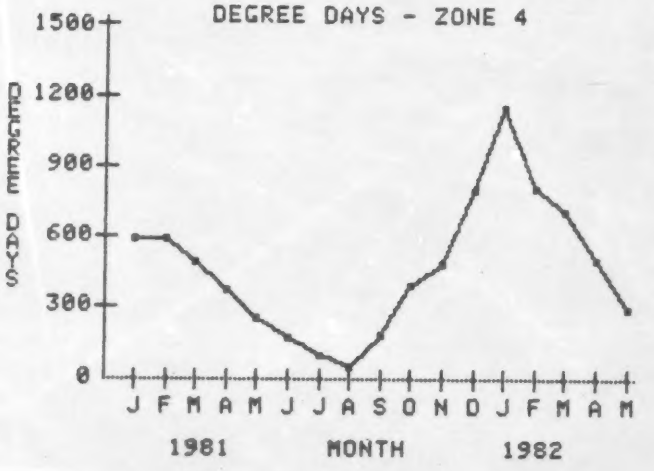
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
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1200
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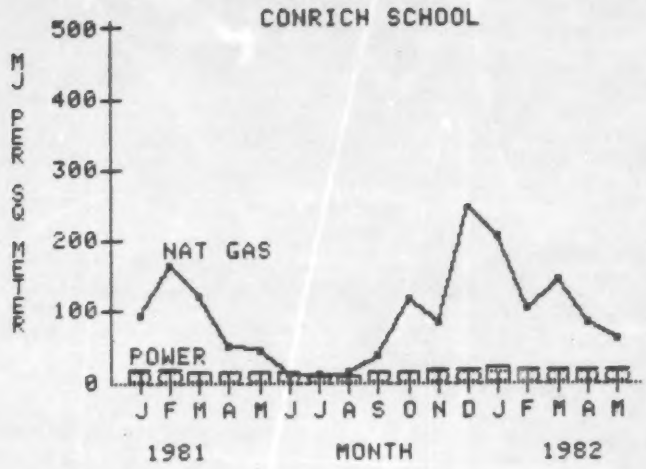
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


CONRICH SCHOOL
MJ PER SQ METER
500
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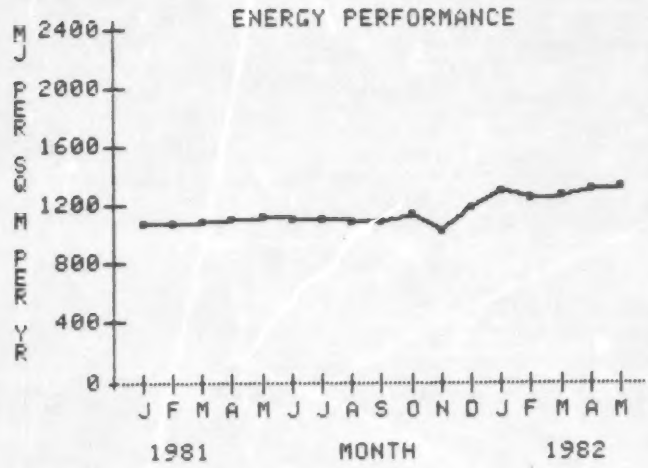
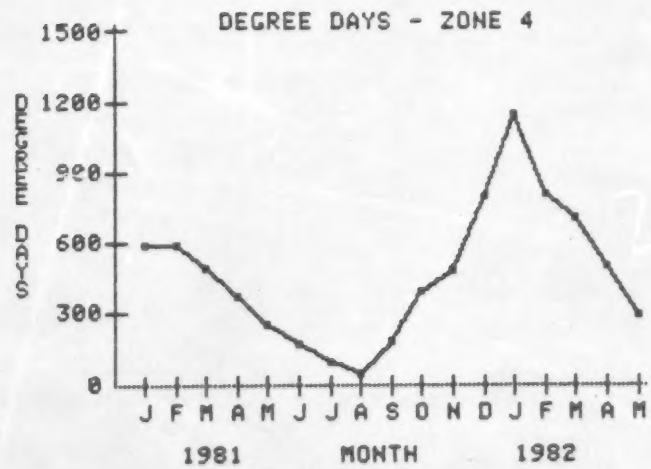
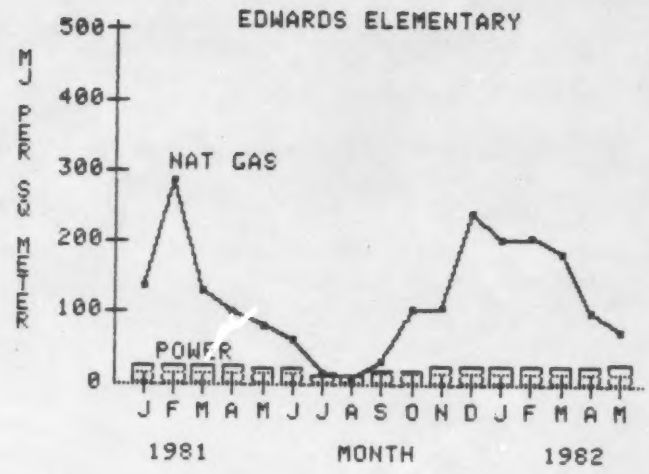
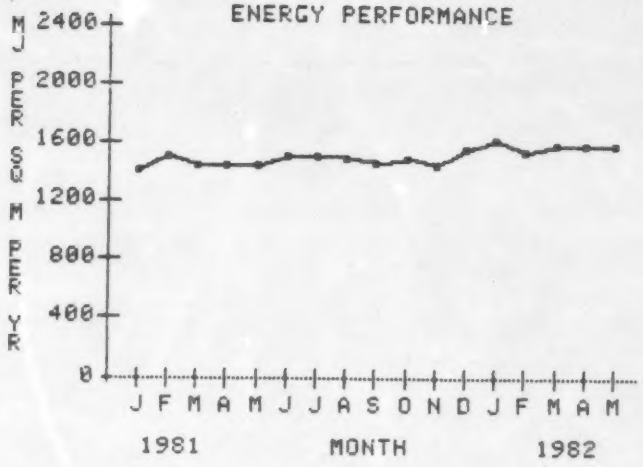
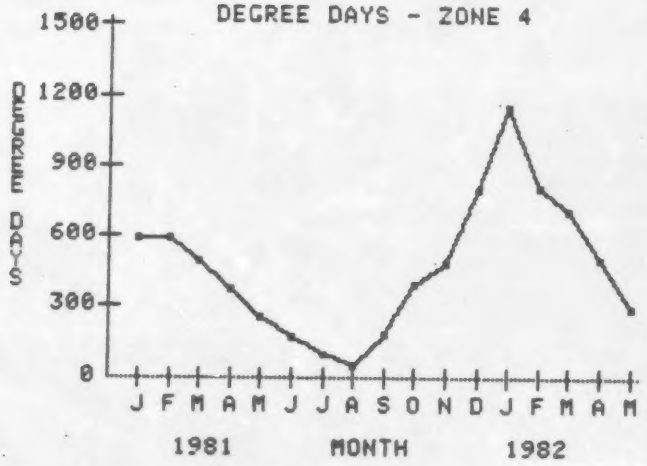
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

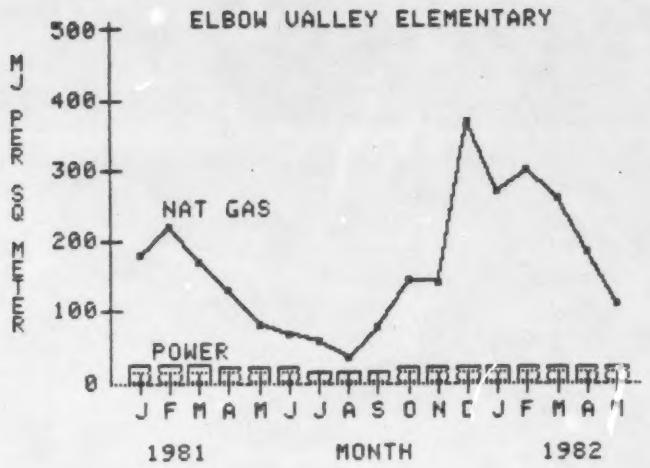

ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


EDWARDS ELEMENTARY
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ELBOW VALLEY ELEMENTARY
MJ PER SQ METER
500
400
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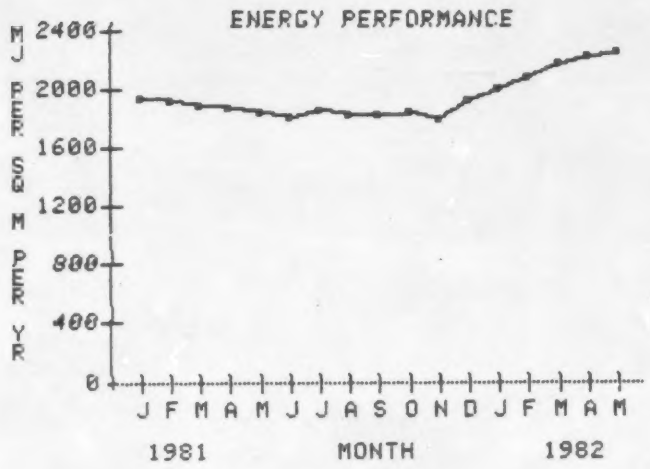
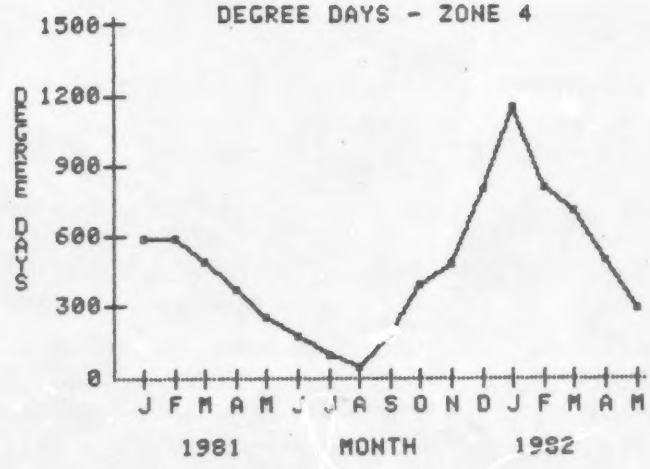
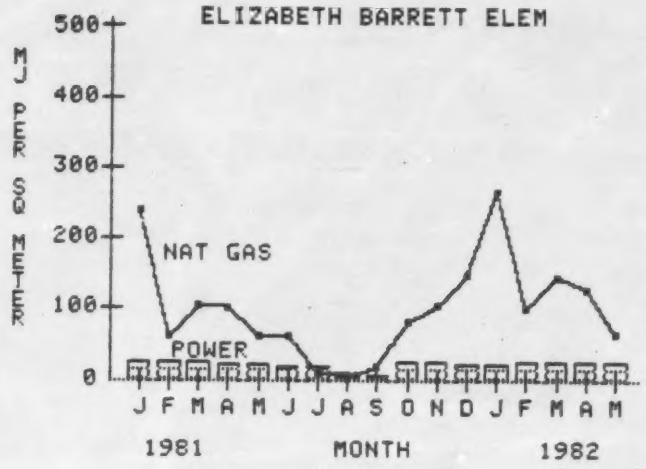
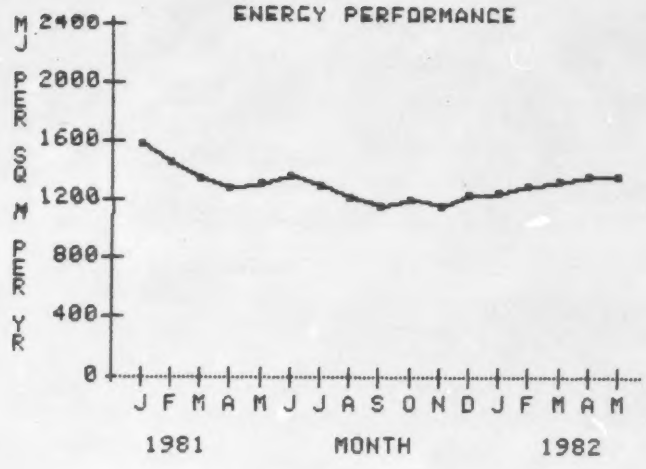
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ELIZABETH BARRETT ELEM
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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2000
1600
1200
800
400
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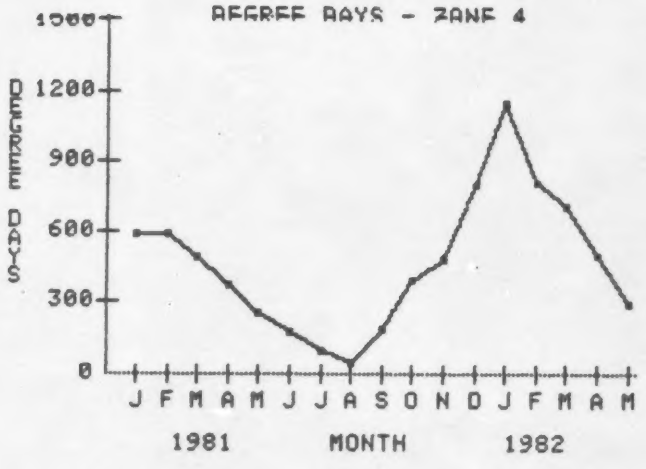
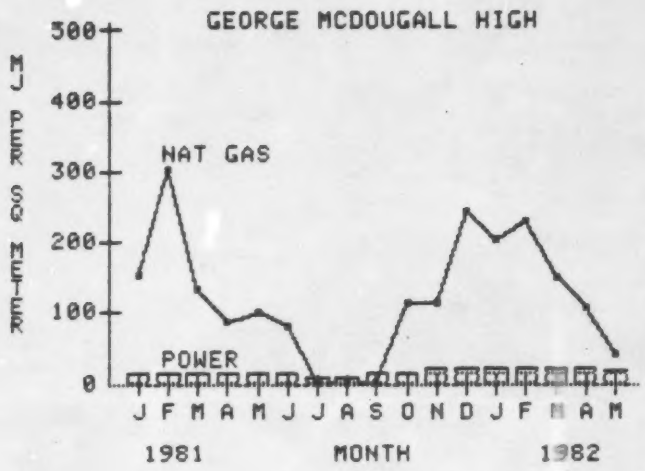
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


GEORGE MCDOUGALL HIGH
MJ PER SQ METER
500
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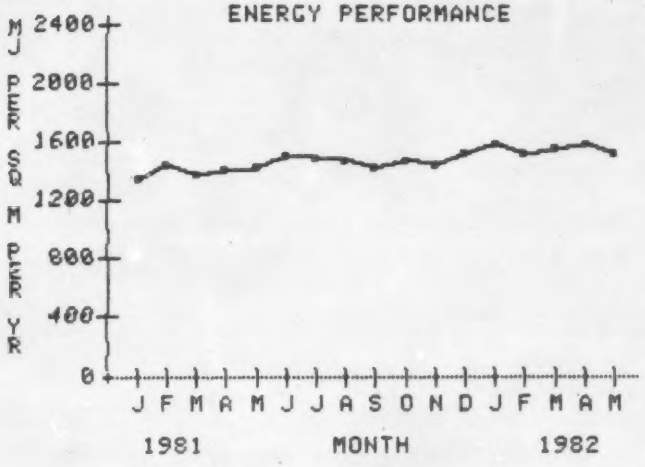
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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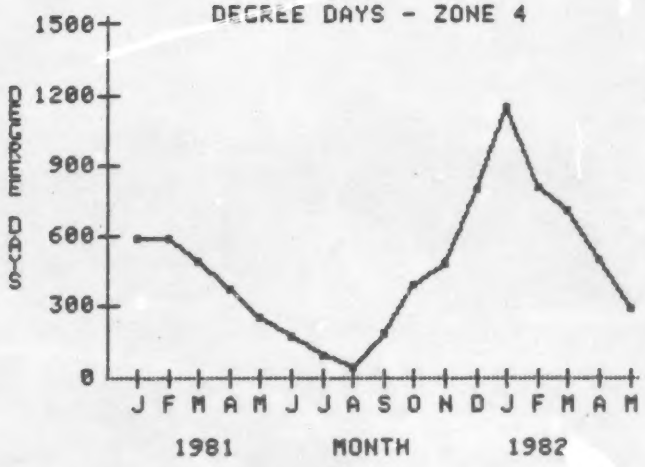
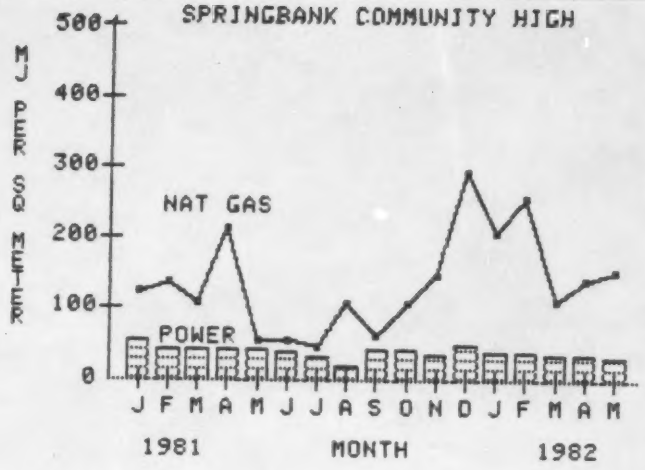
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 4
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


SPRINGBANK COMMUNITY HIGH
MJ PER SQ METER
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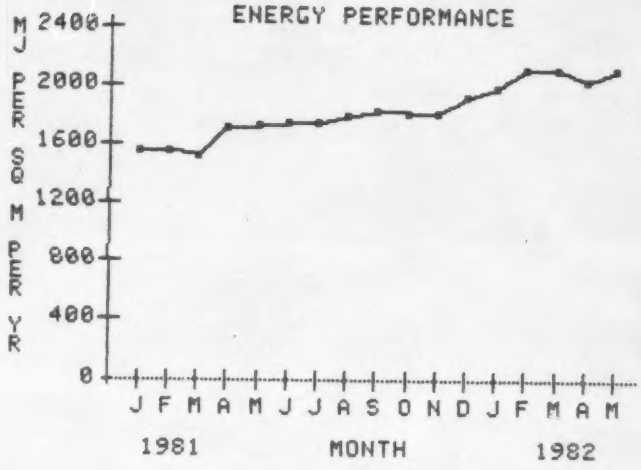
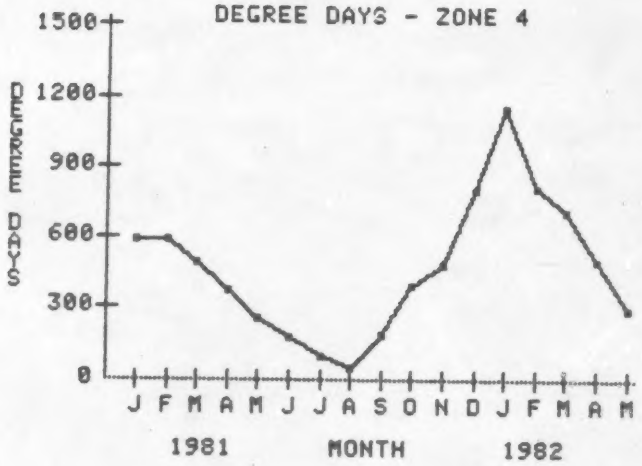
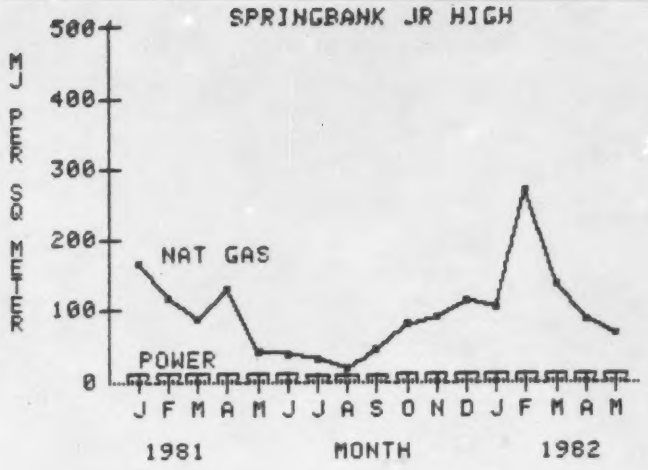
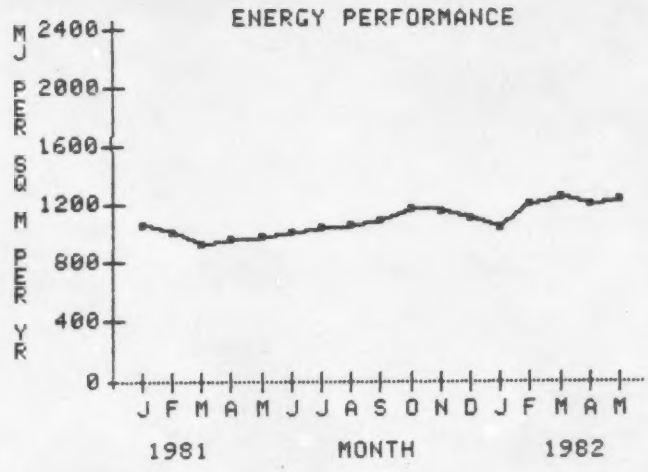
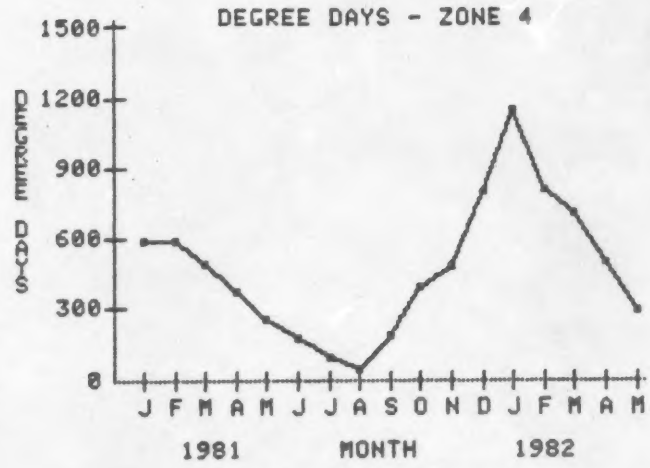
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

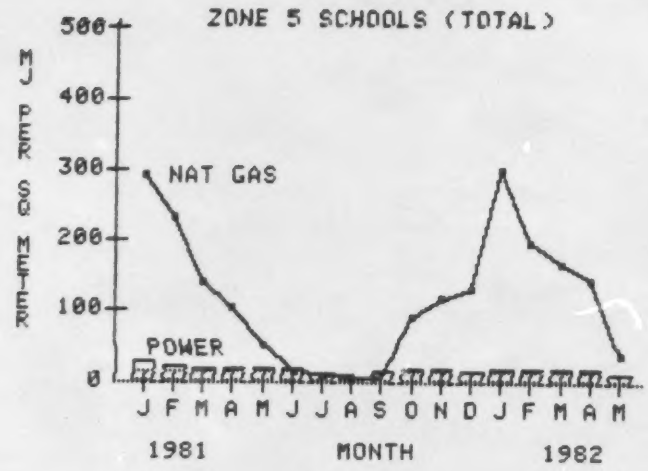

ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

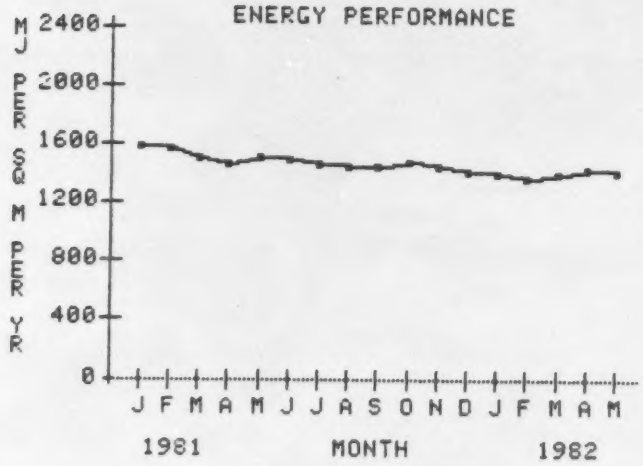

DEGREE DAYS - ZONE 4
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

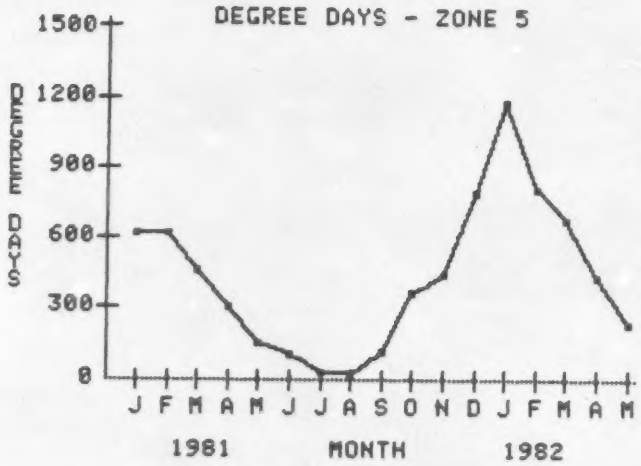

SPRINGBANK JR HIGH
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

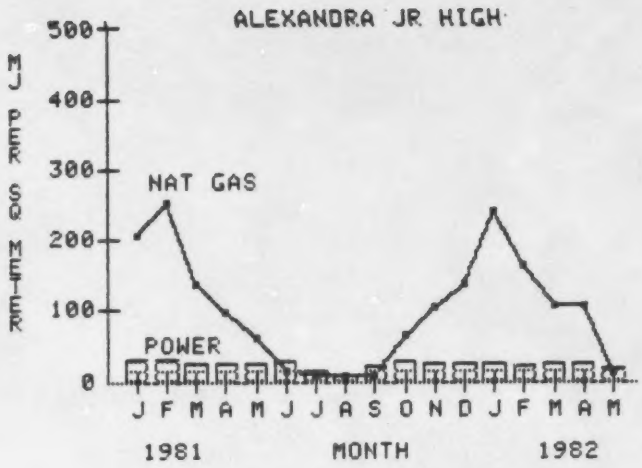

ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

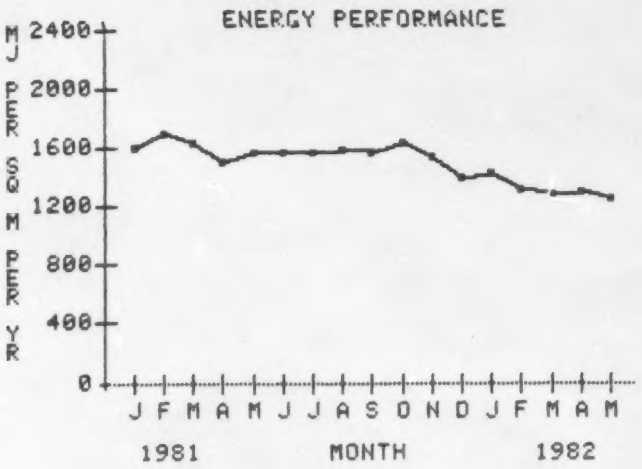

DEGREE DAYS - ZONE 4
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

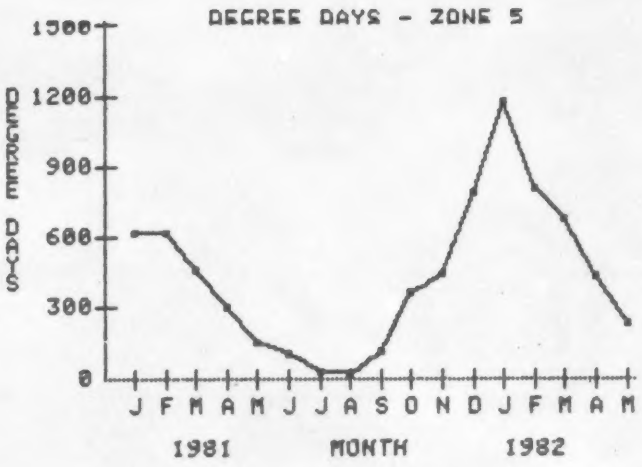

ZONE 5 SCHOOLS (TOTAL)
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

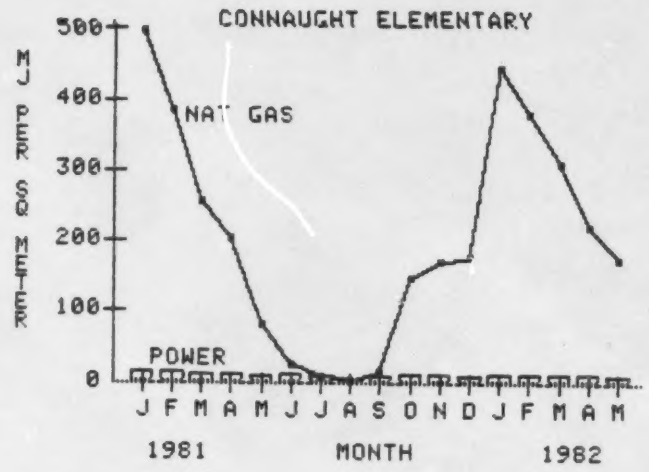

ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

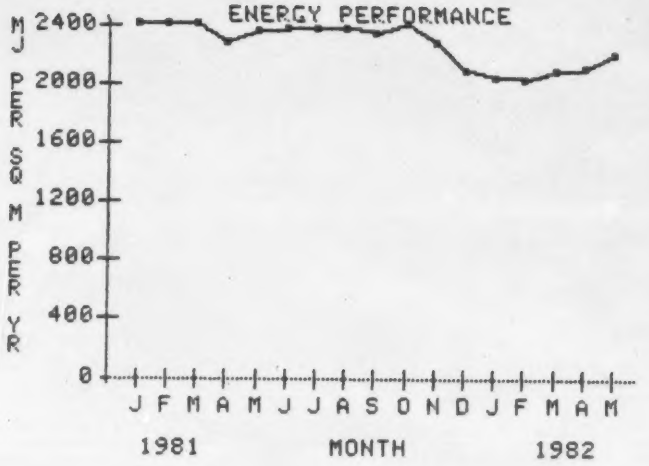

DEGREE DAYS - ZONE 5
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982

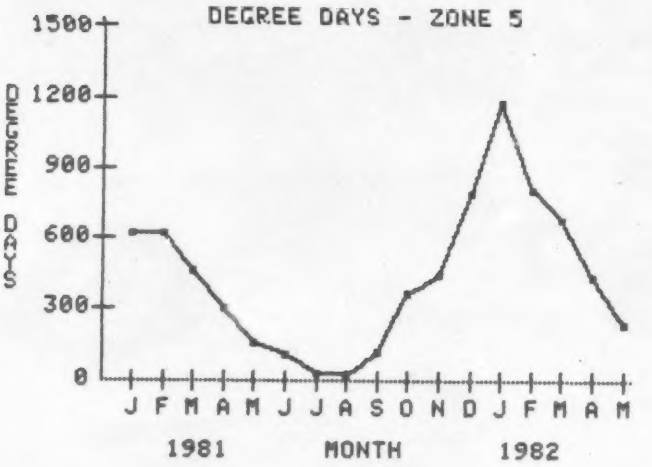

ALEXANDRA JR HIGH
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
1500
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


CONNAUGHT ELEMENTARY
MJ PER SQ METER
500
400
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
2400
2000
1600
1200
800
400
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
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600
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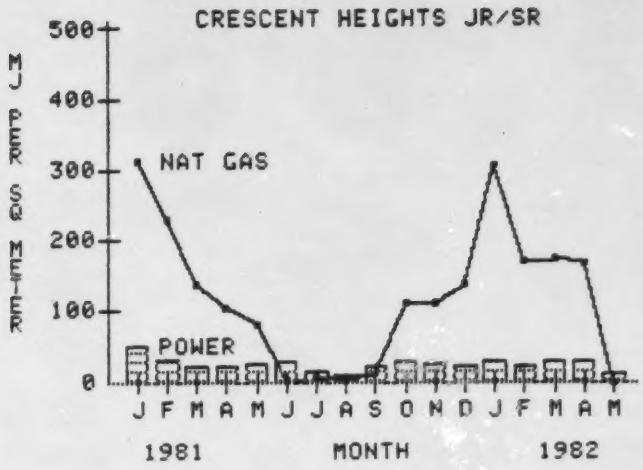
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


CRESCENT HEIGHTS JR/SR
MJ PER SQ METER
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200
100
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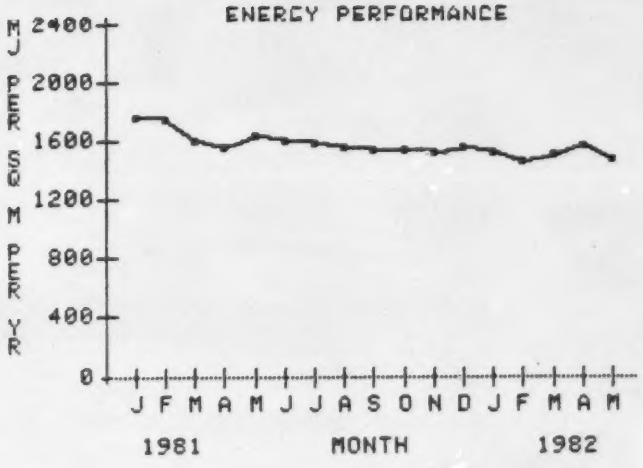
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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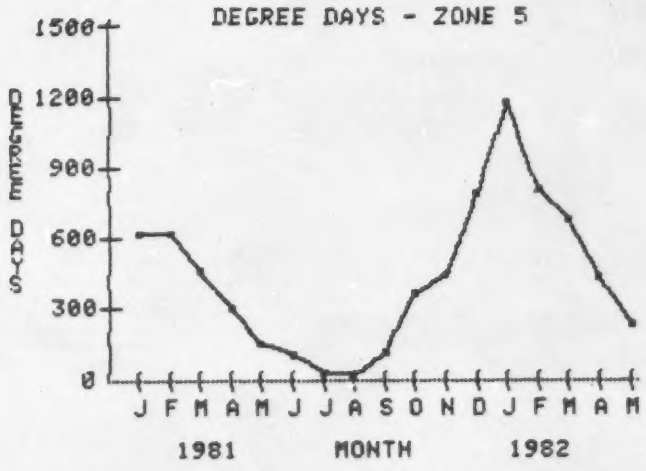
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
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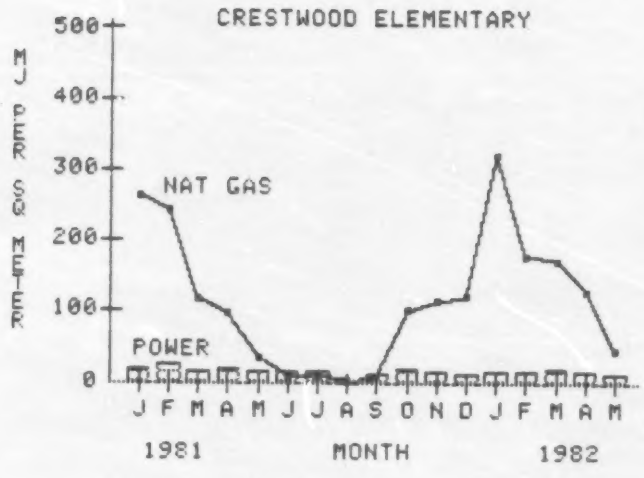
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


CRESTWOOD ELEMENTARY
MJ PER SQ METER
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200
100
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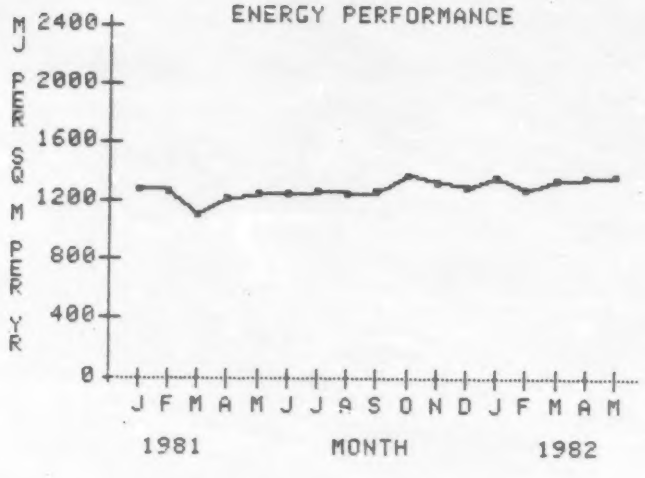
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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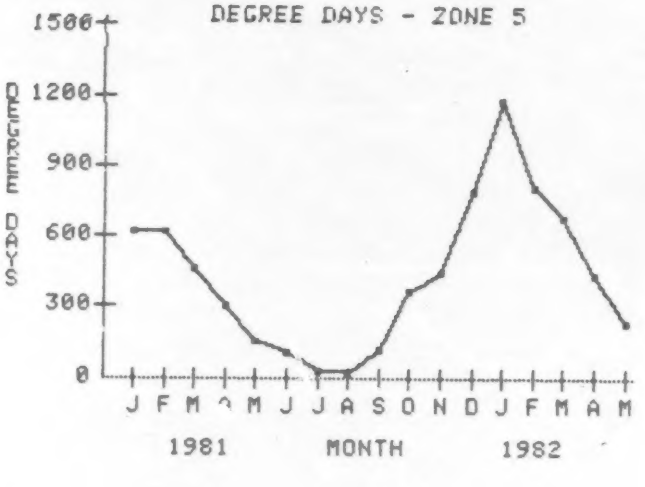
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
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600
300
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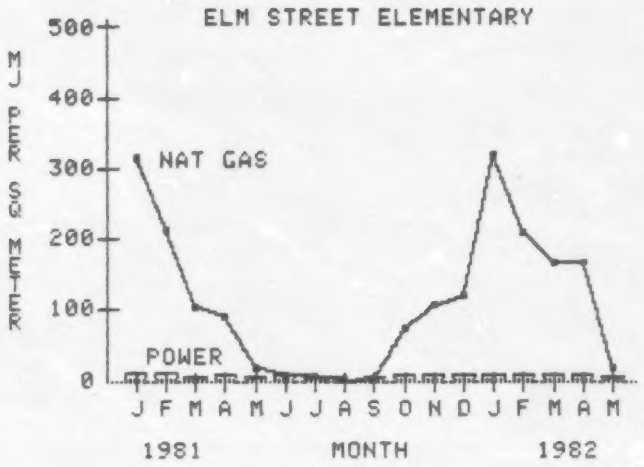
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ELM STREET ELEMENTARY
MJ PER SQ METER
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300
200
100
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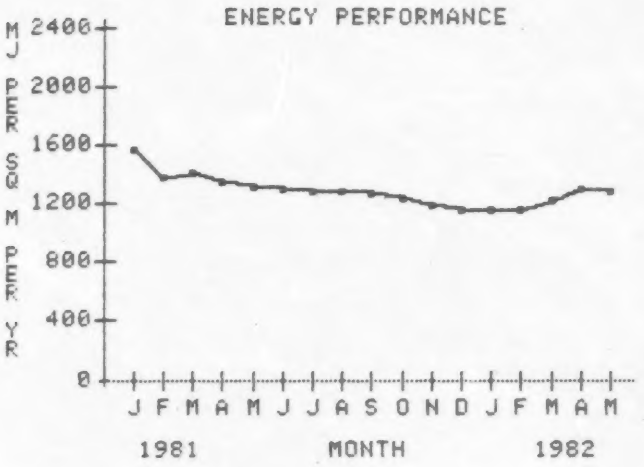
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
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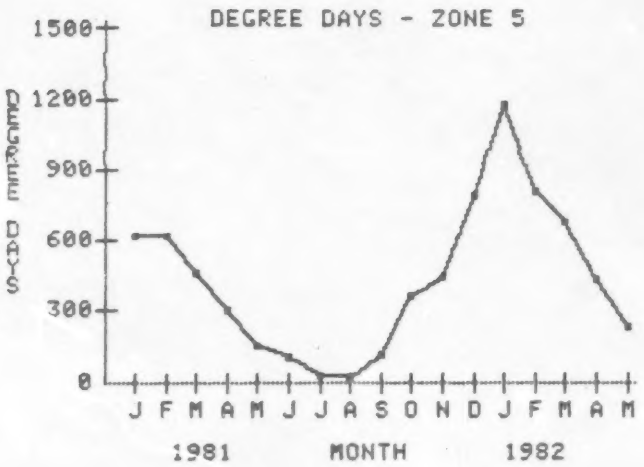
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
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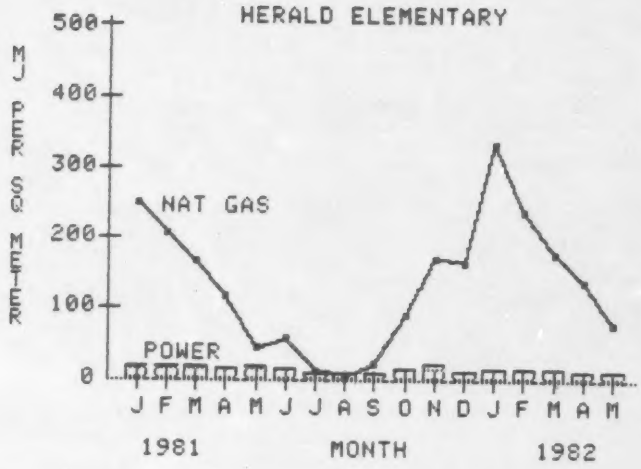
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


HERALD ELEMENTARY
MJ PER SQ METER
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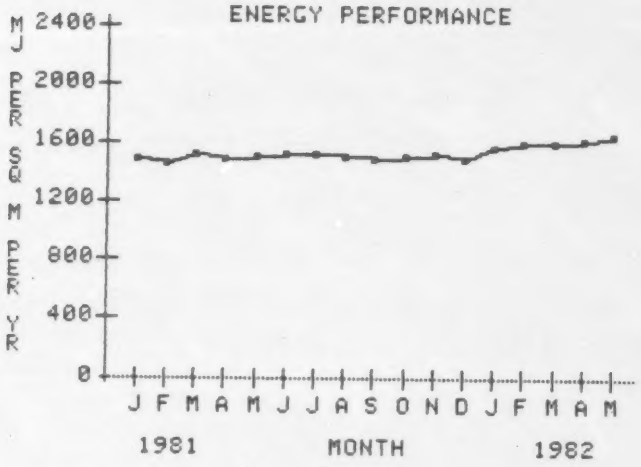
300
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
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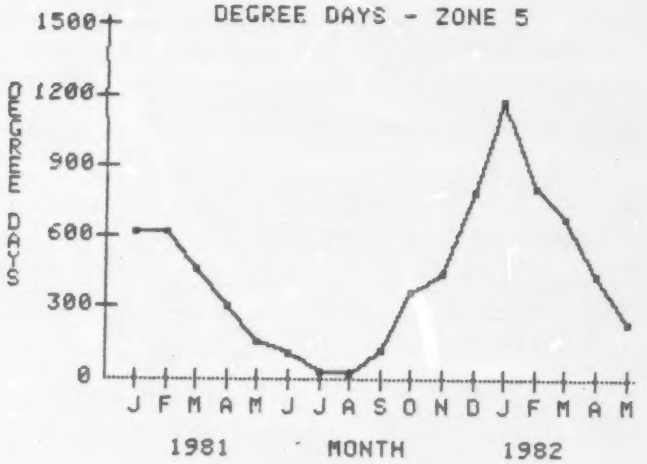
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
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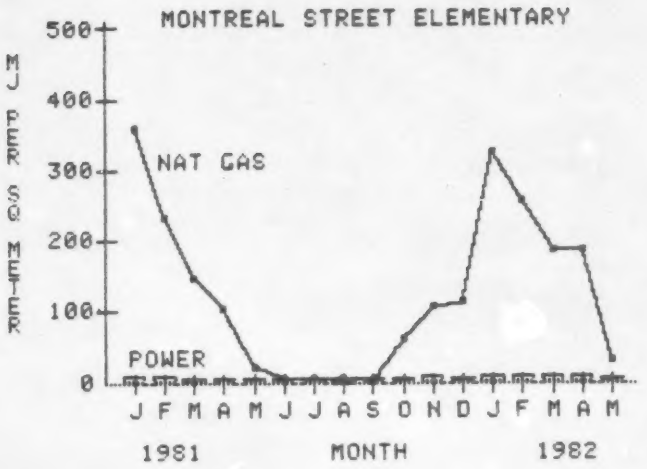
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


MONTREAL STREET ELEMENTARY
MJ PER SQ METER
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200
100
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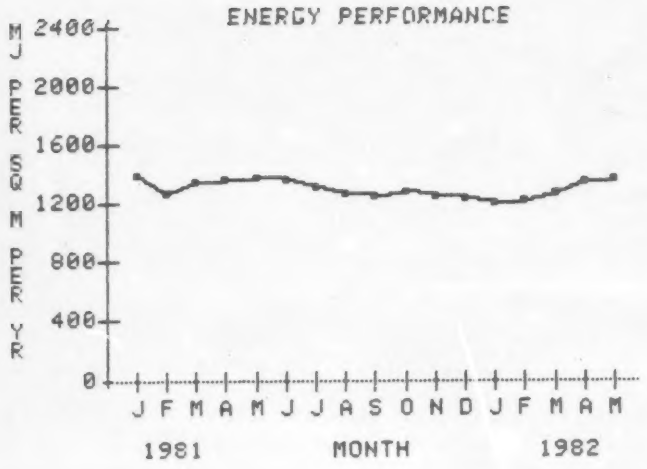
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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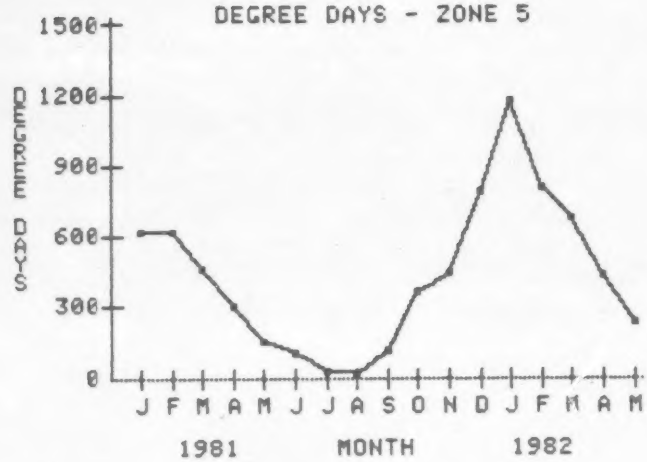
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
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1200
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600
300
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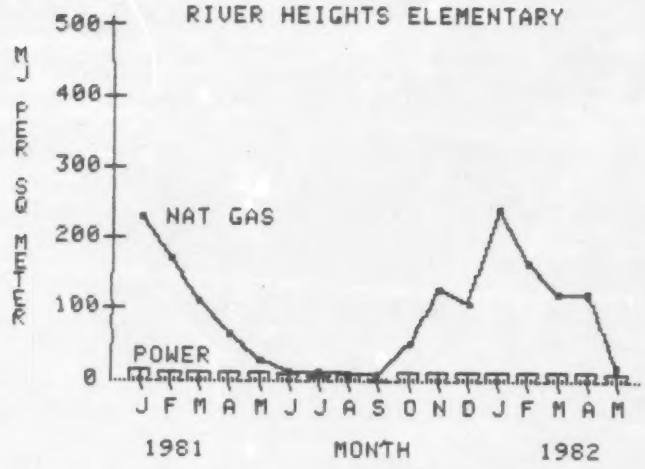
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


RIVER HEIGHTS ELEMENTARY
MJ PER SQ METER
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100
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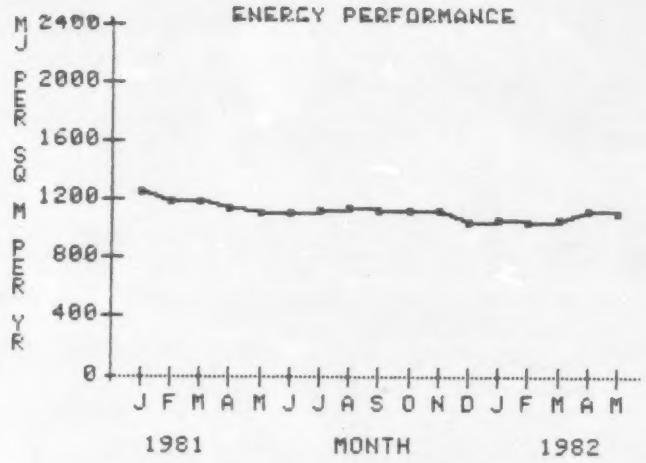
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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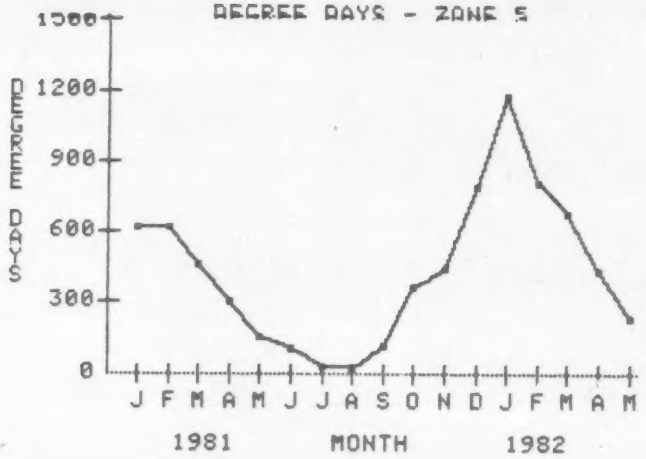
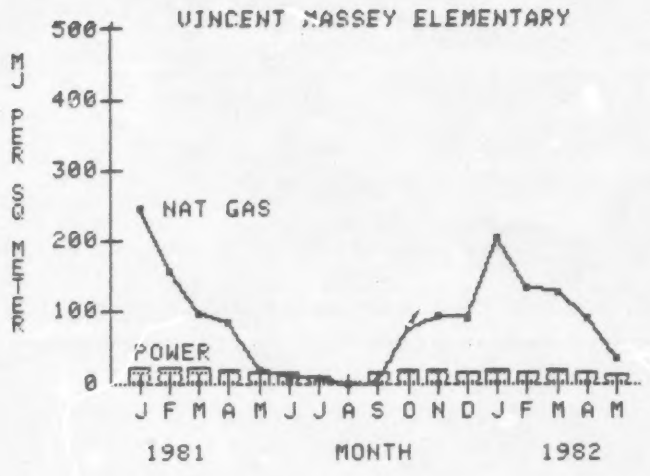
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


VINCENT MASSEY ELEMENTARY
MJ PER SQ METER
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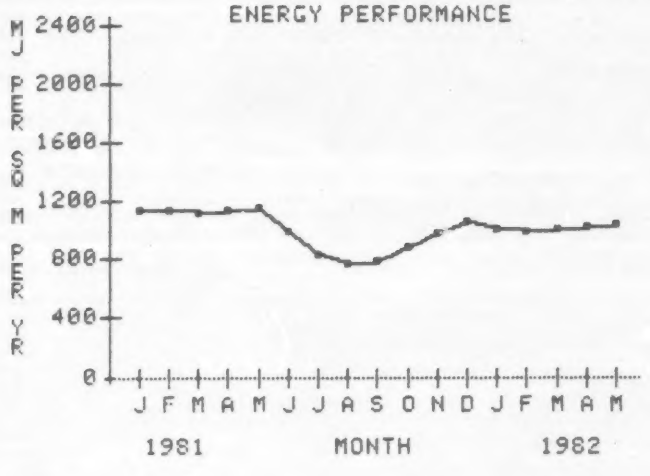
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
MJ PER SQ M PER YR
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1600
1200
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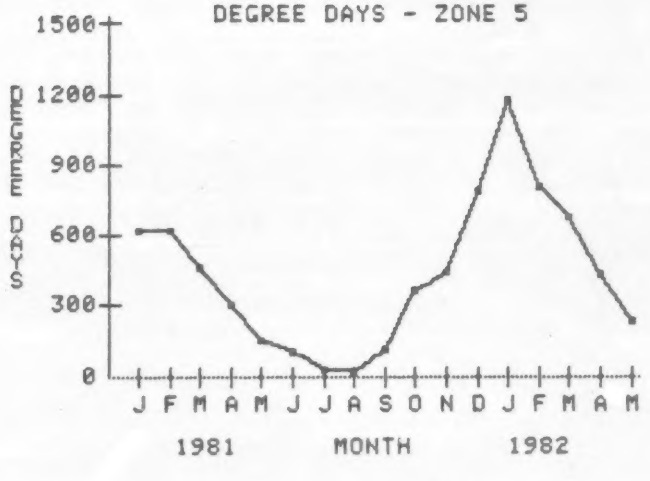
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
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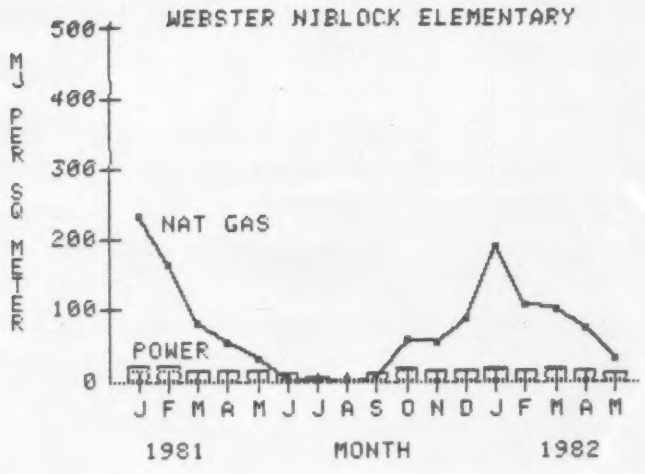
1200
900
600
300
0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


WEBSTER NIBLOCK ELEMENTARY
MJ PER SQ METER
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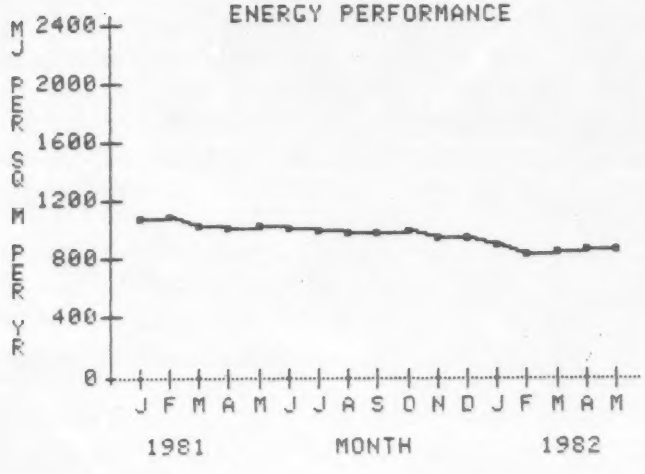
200
100
0
NAT GAS
POWER
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


ENERGY PERFORMANCE
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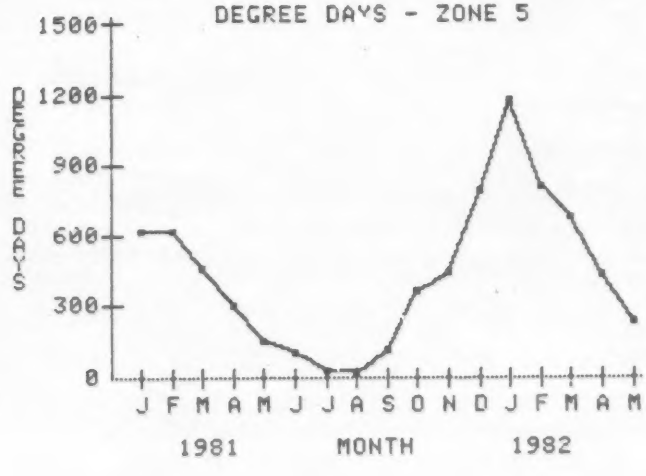
J F M A M J J A S O N D J F M A M
1981
MONTH
1982


DEGREE DAYS - ZONE 5
DEGREE DAYS
1500
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600
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0
J F M A M J J A S O N D J F M A M
1981
MONTH
1982